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MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA

LIFE-HISTORIES OF INDIAN INSECTS—IV (HYMENOPTERA)

BY

GOBIND RAM DUTT, B.A.

Assistant to the Imperial Entomologist

AGRICULTURAL RESEARCH INSTITUTE, PUSA

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PREFACE

This Memoir, which has been written by Mr. G. R. Dutt, Assistant in the Entomological Section at Pusa, deals with the life-histories of some of the Hymenoptera found at Pusa and gives short notes on their habits.

The arrangement and nomenclature of the species dealt with are those followed in the volumes on Hymenoptera in the Fauna of British India series.

Illustrations previously used in *Indian Insect Life* are marked "I. I. L.": those not so marked are original.

PUSA.
18th April 1912.

T. BAINBRIGGE FLETCHER.
Offg. Imperial Entomologist.

ERRATA.

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MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA.

LIFE HISTORIES OF INDIAN INSECTS—IV (HYMENOPTERA)

On page 192, lines 5 and 6 from top

For narrowly, and the hypopygium two large lateral spots on the 7th segment, yellowish white, etc.

Read narrowly, two large lateral spots on the 7th segment and the hypopygium, yellowish white, etc.

On page 258, line 13 from bottom

For *the word* pupa *read* pupæ.

On page 262, line 6 from top

For margin. On the outer surface, etc.

Read margin, and on the outer surface, etc.

LIFE HISTORIES OF INDIAN INSECTS: (HYMENOPTERA).

BY

GOBIND RAM DUTT, B.A.,

Assistant to the Imperial Entomologist.

FAMILY MUTILLIDÆ.

Mutillids, otherwise known as Velvet-ants, on account of the velvety pubescence on the abdomen of the females, are commonly seen at Pusa from March to October, every year. Males have long graceful wings, generally smoky in colour, but the females are wingless. The former are seen flying about on plants, and the latter running about on the ground like ants, from which they are distinguished by the absence of nodes, between abdomen and thorax, which are so conspicuous in the ants. Whenever a male Mutillid is observed flying close to the ground with wings well spread out, head sometimes drooping, sometimes raised, just skimming over the surface of the soil, now touching it, now receding, it is probably in search of a female wasp. On finding her, it swoops down and carries her off by the neck. Pairing may take place at any convenient locality, on a branch of a tree, or elsewhere. If disturbed, they usually fly away together; it is seldom that they part. The fact that the male shakes the female at intervals, mentioned on p. 187 of Mr. Lefroy's 'Indian Insect Life,' has been observed by me in the case of *Mutilla sexmaculata*, Swed.

Female Mutillids sting badly: the sting is very poignant, but causes no appreciable swelling. I was once stung by *Mutilla durga*, Bingh. ♀ in the palm of my right hand; the pain caused was very severe, but lasted for only 5 or 6 minutes.

Mutillids lead a parasitic life upon other Aculeate Hymenoptera. I bred from the cells of *Sceliphron madraspatanum* (F.) a Mutillid wasp which is identical with *Stenomutilla oglana*, Cam., in all its structural features, but has the basal abdominal segment black, not red.

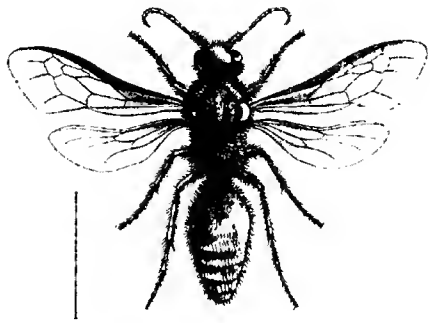


FIG. 1. MUTILLA SEXMACULATA, MALE.
(I. I. L.)

Mutilla poonaensis, Cam. ♀, *Mutilla metallica*, Cam. ♀, and *Mutilla yerburyi*, Cam. ♂, were reared, from broken clay cells which were unmistakably those of Eumenid wasps.

Mutilla regia, Sm. ♂ & ♀ were reared from the cells of *Eumenes conica*, F., and once from below the sandy soil where *Bembex orientalis*, Handl., *Philanthus pulcherrimus*, Sm., and *Palarus* spp. were nesting, I obtained a cocoon from which emerged a very pretty female Mutillid, probably, an undescribed species (Pl. XIV. Fig. 6).

Economic. Excepting the cases quoted above, it is not known what other species are parasitised by Mutillids, and this is the chief point about which definite and accurate information is required, before the economic value of this family can be determined. Secondly, we should also ascertain the economic position of the parasitised species, *i.e.*, whether they are beneficial, useful, or injurious. The results, based on whatever little has been investigated

by me on the subject, in individual cases, are given below. As aforesaid *Mutilla regia*, Sm., has been bred on *Eumenes conica*, F. This *Eumenes*, we know, stocks her cells with paralysed caterpillars, which are generally injurious insects. *Mutilla regia*, Sm., is therefore an injurious insect in as much as it parasitises an insect beneficial to us. *Mutilla yerburyi* also for similar reasons is an injurious wasp. Next consider the case of *Stenomutilla oglana*, Cam., which has been bred from the cells of *Sceliphron madraspatanum* (Fabr.). *S. madraspatanum* (F.), stores spiders in her cells; spiders are, I think, beneficial to some extent (*vide* my note on the subject under *Sceliphron madraspatanum* (F.), pp. 213—14). It follows from this that the *Mutilla* in question is a beneficial insect in so much as it checks the spread of an injurious one.

FAMILY THYNNIDÆ.

There is practically nothing on record as to the habits of the Indian species of this family, which contains only two Indian genera, *Methoca* and *Iswara*. Of the former only one species, *Methoca bicolor*, Cam., occurs at Pusa, and of the latter we have only one representative, *Iswara luteus*, Westw., in our collection, the specimen having been taken at Sargodha, Punjab, in July 1906.

Genus Methoca.

Methoca bicolor, Cam.

The female wasps of this species are wingless and walk about actively like ants, constantly moving the abdomen up and down. The resemblance of this female wasp in shape and colour to the worker of the common black and red tree ant, *Sima rufonigra*, Jerd., is very striking. They differ however in size, the former being constantly smaller than the latter. The doubly constricted thorax of the wasp is easily mistaken for the two abdominal nodes of the ant (Pl. XIV, Figs. 4 and 5).

The name appears to be pre-occupied, having first been used by Say in 1836 (*vide* Boston Journ. Nat. Hist., Vol. I, p. 299). I,

therefore, call this species *Methoca rufonigra*, after the ant which it resembles so closely.

FAMILY SCOLIIDÆ.

There is very little on record as to the habits of the Indian species of this family also. At Pusa representatives of all the genera excepting one (i.e., *Liacos*) are found. *Myzine dimidiata*, Guér., *Scolia quadripustulata* (F.), *Elis annulata* (F.) and *Elis thoracica* (F.) are amongst the commonest species obtained here. During the months of July and August the male wasps are seen in large numbers hovering on flowers, or on grass under the shade of trees, and from March onwards the female wasps are seen flying singly close to the ground, probably in search of beetle grubs, which they have been known elsewhere to parasitise. Only on one occasion, while digging up an ant colony situated on sandy soil where I used to observe *Elis thoracica* hover and disappear in the soil, I secured a hard oval black cocoon, very similar to a dried ball of goat's dung. It did not look at all like a cocoon, and while I was pressing and examining it, it broke in my fingers and the resting larva inside was badly injured.

The cocoon may not be of *Elis thoracica* or of any other Scoliid wasp, but the facts that *Elis thoracica* was constantly flying there and that I obtained cock-chafer grubs (which are believed to be parasitised by the wasps) from the same locality, make it a possibility. However, on such frail grounds I cannot express an opinion.

Relation between Myzine dimidiata Guér. *and M. madraspatana*, Smith.

I have made a series of observations on the above subject. On 1st July 1908 I noticed *Myzine dimidiata* flying in large numbers over dead and dried leaves under a *Sarish* (*Albizzia lebbek*) tree. All the specimens captured proved to be males without any exception. I could not guess what they were about—was it mere frolicking or what? The only thing they did was to sit occasionally on a blade of grass for a couple of minutes and to fly away again.

I watched them daily for some time. On 10th July 1908 I marked *M. madraspatana* ♀ flying there. One *dimidiata* ♂ jumped on her knocking her down and then flew away. Another *dimidiata* ♂ followed suit, but nothing of any consequence happened. This made me suspect some relation between the two. On another occasion I saw a *dimidiata* ♂ sitting quietly over pieces of broken bricks for an unusually long time. I went nearer and saw something moving below. On closer examination it was found to be a winged insect, and when the *dimidiata* flew away I discovered that the hidden wasp was no other than *M. madraspatana*. This incident supported my former conjecture. I continued watching them, and at last on 15th July 1908 I caught *dimidiata* ♂ and *madraspatana* ♀ actually coupled.

Two important conclusions can be drawn from the above observation :—

(*i*) that *M. dimidiata* and *M. madraspatana* are not two distinct species but are male and female of the same species, or

(*ii*) that in this genus males and females of different species can breed together indiscriminately.

I support the first inference for the reason that the late Col. Bingham, in the "Fauna of British India, Hymenoptera," Vol. I, divided the genus *Myzine* in two parts :—

(*A*) Females only known.

(*B*) Males only known.

M. madraspatana is mentioned under *A*, and *M. dimidiata* under *B*.

It appears that these wasps were never captured before "in cop," and since there is not the least resemblance between the two in colour and shape they were described as distinct species. Difference in colour is a matter of no great consequence in the determination of sexes amongst Scoliids. We find in *Elis annulata* ♂ and ♀ another instance of the same kind. The male is smaller and

more slender than the female and bears transverse yellow bands on the posterior margin of the abdominal segments, whereas the female is robust, and black with white pubescence.

FAMILY POMPILIDÆ.

Genus Macromeris.

Macromeris violacea, Lepel.

In the "Fauna of British India, Hymenoptera," Vol. I, the late Col. Bingham remarked regarding this genus as follows: "The habits of the species belonging to this genus are almost unknown. Once I observed a female carrying a large hairy spider (*Heteropoda venatoria*) to a chink in a deserted wooden house, in the forests in Tenasserim, and there is no doubt she was storing these as food for her future progeny." By the time of the publication of Mr. Lefroy's 'Indian Insect Life' I had obtained only larvæ and pupæ of this wasp, and the limbs of a spider in one cell. Since then cells containing eggs have also been found, and I have succeeded in studying one life cycle of this interesting and rare wasp which is as follows:—

The female wasp constructs dark brown cells in hollows or under the raised portion of bark of old trees. At one and the same spot as many as half a dozen of these cells may be found. The general shape of these cells is long oval, length about 22 to 26 mm. and breadth about 15 to 17 m m. (Fig. 2). Materials used by the wasp in constructing these cells are various, *e.g.*, clay, sand, chewed

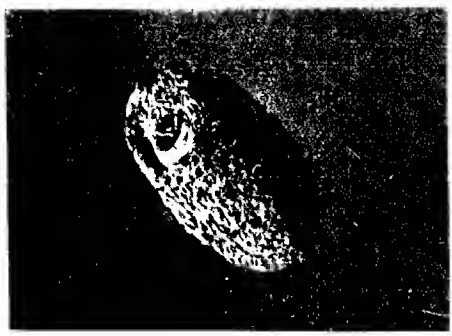
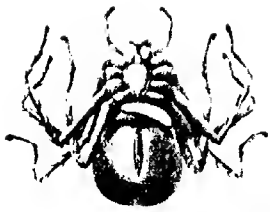


Fig. 2. A Cell of Macromeris violacea ×1½ (I. I. L.)

PLATE XI.



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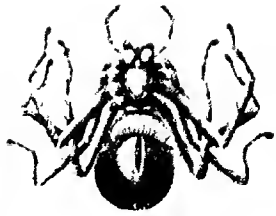

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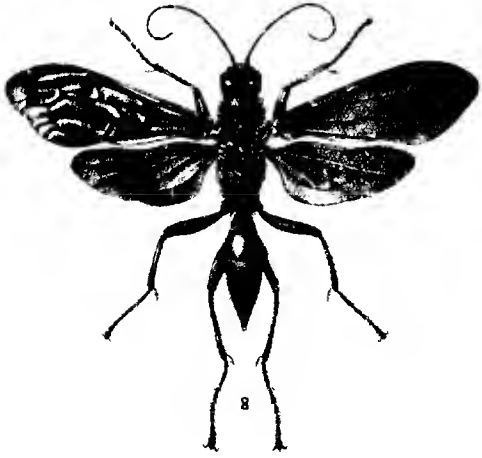

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EXPLANATION OF PLATE XI.

Macrocnemis violacea, Lepel.

1. Spider bearing an egg of the wasp.
2. Two days' old larva of the wasp.
3. Full grown larva, dorsal view.
4. „ „ „ side view.
5. „ „ „ spinning cocoon inside a cell.
6. Pupa, dorsal view.
7. „ side view.
8. Imago, flying attitude.

All figures magnified × 2.

up vegetable matter, some gummy substance, etc. The outer surface of these cells is rough and rugged, granular and superficially ridged, but the inside is quite smooth. The front near the upper end is flattened and is thinner than the rest of the cell, and it is this portion which is pierced by the wasp at the time of emergence. The lower end of a cell is stuck on one side against the trunk of a tree and the remaining part of the cell stands out at an acute angle.

In each cell a single big spider is stored and on its ventral side near the base of the abdomen is laid an egg. (Pl. XI, Fig. 1). The egg is milky white, long and a little curved ; length is 5 mm. and breadth a little more than 1 mm.

The egg hatches in about 2 days, and the young larva thrusting its mandibles into the abdomen of the spider begins to lap the body juice. The abdomen consequently shrinks and the posterior spinning-mamillæ become distinctly visible (Pl. XI. Fig. 2). As the larva grows it eats voraciously and the spider is completely finished in four days ; nothing but the claws are left. The larva is full grown then and measures when stretched, 28 mm. long and 6 mm. broad (Pl. XI, Fig. 3) ; the head usually remains doubled below the thorax (Pl. XI, Fig. 4). It tapers gradually towards the head end and at the prothorax it is 2·5 mm. wide. The head is wider than the prothorax and is 3 mm. across. It is light brownish in colour and bears two slightly pinkish lines which converge to the vertex. The apical portions of the mandibles are reddish. The body is divided into indistinctly marked segments and is margined laterally. On each side of the body there are 9 circular spiracles. The integument is transparent, and through this white round particles of fat are seen moving forwards and backwards. The general colour of the larva at this stage is greenish gray. The larva spins a brownish cocoon inside which it pupates (Pl. XI, Fig. 5), but before actual pupation takes place it rests for about 5 or 6 days. The colour of the larva in this 'resting stage' turns to delightful pale yellow and the larva begins to contract a little in size. Below the larval skin becomes visible,

though indistinctly, the future pupa. Ultimately the larval skin is shed and the true pupal stage commences. The pupa is of ivory-white colour and possesses all the limbs of the perfect wasp which are symmetrically folded on the venter (Pl. XI, Figs. 6 and 7). In general form the pupa resembles other Hymenopterous pupa except in one particular, that the abdominal segments are furnished with lateral 'Y' shaped processes. Of what use are these to the pupa I cannot venture to say definitely, but I fancy that the abdomen when resting inside the cocoon on these 'forks' is very secure. Gradually changes in the colour of the pupa set in from the head side. The eyes turn pinkish to begin with and then blackishness appears on them and also on the thorax. This black colour slowly spreads towards the abdomen till on the 11th or 12th day the whole insect becomes quite black. On the 13th or 14th day after pupation the thin pellicle covering the pupa is shed and the wasp emerges (Pl. XI, Fig. 8). It leaves the cell a day afterwards on getting dry. Thus from egg to imago it occupies about 4 weeks.

Egg stage	2 days.
Larval stage ... ... (including 'Resting stage')	10—11 days.
Pupal stage	14 days.
	26—27 days.

Genus Pseudagenia.

Among the species belonging to this genus those found at Pusa are *P. blanda* (Guér), *P. clypeata*, Bingh., *P. lœvicula*, Bingh.. *P. ægina* (Smith) and two undetermined species; but none of them is common.

Pseudagenia blanda (Guér.)

Pseudagenia blanda ♀ constructs clay cells in places hidden from external view, such as natural crevices, cavities and hollows in big trees or under their bark, etc. She is strictly a wasp of the jungle, never coming into our houses like *Sceliphron* or *Eumenid* for nest making. There are only two cells in a nest (so far as I have

ascertained) and these are constructed in juxtaposition, one cell being smaller than the other (Pl. XIII. Fig. 3). From the smaller cell emerges the male (Pl. XIII. Fig. 4 & Pl. XIV. Fig. 2), and the female from the larger one (Pl. XIV. Fig. 1). The male cell is 13 m.m. long and the female cell about 17 m.m. These cells are very similar in shape to those of *Sceliphron madraspatanum*, but are constantly smaller in size. One more peculiarity has been noticed in them that near the top there are invariably fixed some clay balls in the shape of knobs (Pl. XIII. Fig. 3). I cannot guess what utility these are to the wasp excepting that they give to the cells more or less the rough appearance of the uneven surface of the bark of trees on which the cells are constructed.

In each cell one spider of medium size is stored, and on the ventral side of the abdomen near the base the egg is laid transversely. The larva, as usual, on hatching feeds on the spider, after consuming which it spins a thin brownish cocoon inside which it pupates. The wasp emerges through a hole made in the top of the cell.

The male wasp of this species does not appear to have been described yet. I, therefore, describe it as under:

Pseudagenia blanda (Guér.) —(Pl. XIV, Fig. 2).

Head, thorax, and abdomen pruinose: portion behind the eyes, the sides of the pronotum, pleura, and the sides of the median segment covered with longish thin white pubescence, the clypeus large, convex, and its anterior margin slightly sinuate: eyes converging both above and below. Pronotum short, slightly transversely sulcate along the posterior margin: median segment long rounded with a gradual slope to the apex, transverse wavy striations along its middle portion which is without pubescence, its anterior lobe is deeply longitudinally impressed and bears faint transverse striations; legs long without spines, calcaria of the hind tibiæ about as long as the 2nd tarsal joint, abdomen fusiform. Bluish (in certain strong lights black with a bluish bloom) with a thin silvery pile; the palpi, labrum, mandibles at apex, clypeus

except a dark brown spot in the centre, face to a little above the base of the antenna in the middle and up to the vertex along the inner orbits of the eyes, the scape of the antenna in front, all the coxæ in front, apical margins of segments 1 to 6 of the abdomen narrowly, and the hypopygium two large lateral spots on the 7th segment, yellowish white; abdomen black with a bluish bloom; base of the mandibles and antennæ black; the femora orange red, the tibiæ and tarsi dusky brownish black; wings hyaline and iridescent, apex of the forewing narrowly fuscous; nervures and tegulæ testaceous.

Length 8·5 mm. Exp. 14 mm.

Economic.—This wasp constructs cells in pairs, but it is not known how many such pairs are built by one wasp. If after constructing the first pair of cells, she dies or is incapable of laying more eggs, I should class her as neutral from an economic point of view. We have seen she lays up a single spider in a cell, and as this wasp is never abundant at any time of the year, the number of spiders destroyed is insignificantly small. Consequently the harm done by this wasp is negligible.

Pseudagenia clypeata, Bingh.

The nesting habits of this wasp are very interesting, and I cannot do better than quote here one of my observations on the subject.

Fig. 3. Nest of sceliphron coromandelicum occupied by Pseudagenia clypeata ×⅔ (I. I. L.)

"From a very big clay nest (Fig. 3), removed from a hollow in a tree, emerged *Pseudagenia clypeata*, male and female. The nest appeared to be decidedly that of some *Sceliphron* wasp, probably of *S. coromandelicum*

(Lepel), but the emergence of the *Pseudagenia*, which is not a parasite, was indeed puzzling.

"The first essential thing to determine was what species had originally constructed the nest. Of all the mud-nest constructing wasps found at Pusa, *Sceliphron coromandelicum* alone could make such a big nest. However to ascertain this I closely examined the underside of the nest. If it were actually the nest of *Sceliphron coromandelicum*, I argued, there must have been a few large cells of equal size more or less in a line. No doubt there was one big empty cell visible on the underside. On the right hand side of this cell I removed a little clay with a knife: a cavity appeared, and I opened it little by little till the cavity proved to be another cell (of the same size as the first one) containing broken limbs of spiders. Similarly on the left hand side of the 1st cell I opened another cell of the same size containing dried and broken limbs of a wasp, but from these broken limbs, the wasp could not be definitely determined. Thus seven cells were discovered in one line, and from one of these I obtained a rotten specimen of *Sceliphron coromandelicum* covered with fungus growth. This decided one point.

"Again, in some of the cells I found empty brown cocoons of the *Sceliphron* containing small clay cells in which were seen thin yellowish empty or inhabited cocoons.

"In some cases in a single cell of the *Sceliphron* there were noticed two smaller clay cells, each containing a full grown larva or a pupa in a thin yellowish cocoon. Again, all round these seven cells and on the margin of the big nest, smaller cells containing the above mentioned larvæ and pupæ in cocoons were discovered.

"From the above mentioned facts I conclude:

1. That the nest was originally constructed by *Sceliphron coromandelicum*:

2. That when the wasps had emerged from almost all the cells the empty cells were utilized by *Pseudagenia clypeata* for nesting;

3. That when all the empty cells were occupied more cells were added on to the margin all round." *

It may be interesting to know how to distinguish externally a *coromandelicum* nest occupied by *P. clypeata* from a nest which is unoccupied. The test is simple : *Sceliphron coromandelicum* is a much bigger and stouter wasp than *Pseudagenia clypeata*. Naturally enough the former is capable of carrying much greater quantity of mud at one time than the latter. Thus when mud pellets are thrown at random on the completion of the nest by the *Sceliphron*, the nest assumes an ugly appearance of one lump of mud, whereas the *Pseudagenia* covers the outer surface of the nest all over with fine small round clay balls which are laid regularly side by side (Plate XIII, Figs. 1 & 2).

In a cell of *Pseudagenia clypeata* only one spider of a moderate size is stored. On the underside of the abdomen of the spider the egg is placed transversely, and not inclined to one side of the abdomen as in the case of *Sceliphron* wasps. *P. clypeata* takes particular care to bite off the spider's legs before egg laying ; thus minimizing the chances of destruction of the egg from the leg strokes of the spider administered during moments of convulsive agony, and ensuring to some extent the security of the larva from similar disaster when it is biting into the abdomen of its victim.

The egg is about 2 m.m. long and 0·4 m.m. broad ; white, long and cylindrical with ends rounded. About 6 days after hatching the larva finishes its spider and is full grown. It measures then 9 m.m. long and 2 m.m. broad (one larva measured 10 m.m. long and 3 m.m. broad ; probably this was the larva from which a female wasp was to emerge). General colour of the larva is gray. It looks very similar to the larva of *Sceliphron madraspatanum* in colour and general appearance. The integument is thin and transparent, and through it are visible round white particles

* NOTE.—In July 1909 I removed from a tree a mud nest of *Sceliphron coromandelicum* from which emerged both the wasps *Sceliphron coromandelicum*, and *Pseudagenia clypeata*. It shows that the *Pseudagenia* does not necessarily wait till all the wasps from the cells of a nest have emerged, but occupies or adds her cells on to it even if some of the cells are inhabited by the *Sceliphron* larvæ or pupæ.

(of fat) moving to and fro. The prothorax has not those fleshy tubercles which are so conspicuous in *Sceliphron madraspatanum* (F.) larvæ. That portion of the body representing the abdominal segments is margined laterally and the marginal area is indented, bearing blunt fleshy triangular tubercles. There are 14 segments of the body including the head which is bigger and broader than each of the three succeeding thoracic segments and smaller and narrower than the central ones. On the front there are two slanting brownish lines converging towards the vertex.

The full-grown larva spins a thin yellowish brown cocoon inside which it rests and pupates. As soon as spinning is finished the larva discharges excreta which do not form a long continuous mass as in the case of *Sceliphron* larvæ, but a string of pointed beads. *

Enemies.—Two parasites have been bred from *Pseudagenia clypeata*, one Hymenopterous (Ichneumonidæ) and the other Dipterous (*Hyperalonia* sp.) The full-grown larva of the former spins a separate thin white cocoon in the cell of the host, while the latter pupates inside the wasp cocoon. Once the *Hyperalonia* maggot gets at the wasp larva, the former finishes the latter within three or four days' time and rapidly increases in size (Fig. 4). When full grown its length is 11·5 m.m. and breadth 3 m.m. at its widest portion. General colour is yellowish white. The distinctly marked segments of the body are ten; but on taking into account the faint transverse impressions, on the ventral surface, they number twelve. The anterior portion is rounded, smooth. There are no mouth parts visible, but just in the centre on the front side, there is seen (under a microscope, of course) a thin curved beak-like process, reddish-brown in colour. On either side of the 1st anterior segment is visible a spiracle, semi-circular in shape. On the last segment but one on either side, there is another spiracle circular in form. The integument is very thin and transparent. Below are almost round white particles of fat accumulated together and arranged

* Note.—This holds good only when larvæ are put in an open glass crucible where they cannot spin a regular cocoon.

in beautiful indented patterns near the middle portion of the segments. The full grown maggot rests inside the *Pseudageni* cocoon in a curved position. Resting period lasts from 5 to 6 days in summer, after which the maggot casts off its skin; and this is an indication that the pupal stage has commenced. The pupa is quite a curious object. It has no similarity either with the maggot or the fly. The head end is furnished with 8 spines, the tail with two, the body with long reddish brown hair, and the middle segments above with backwardly-pointing thick short spines. There are eight ear-shaped spiracles on either side of the body: but there are no spiracles on the first and last segments (reckoning from the head end). The pupa is of a yellow colour in the beginning (excepting the spines and hair which are reddish brown), but gradually the head, thoracic segments (and wing pads) turn dark brown and become darker till just before emergence of the fly these parts become very dark brown approaching to blackness.

FIG. 4. LARVA OF HYPERALONIA SP. IN RESTING STAGE, LYING NEAR THE DESTROYED PSEUDAGENIA LARVA SHOWN ABOVE IT ×2 (I. I. L.)

The pupal stage lasts for 12 days in summer. Emergence takes place just in the same way as in the case of *Hyperalonia sphynx*, described under *Sceliphron madraspatanum*. But one thing is worth mentioning: when the pupa is lying in a glass crucible on one side, it turns on its back at the time of the emergence of the fly, thus resting on the backwardly-pointing spines with which its back is furnished.

Economic.—Although this wasp also stores a single spider in a cell, yet I will put it down as an injurious insect; for in a single nest there may be as many as eighteen (more or less) cells which means destruction of an equal number of spiders in one brood. In

the following brood there will probably be six females (allowing one-third the number as parasitised and one-half of the remainder as males), each paralysing 18 (more or less) spiders. Similarly in the next brood from each of these six nests six female wasps will emerge, each storing 18 spiders in her nest. Thus there will be an enormous number of spiders paralysed and destroyed by this wasp during a year. The spiders stored in cells being the web-spinning species are useful (*cide* my remarks on the subject under *Sceliphron madraspatanum*).

Pseudagenia spp.

Four clay nests, consisting of small delicate cylindrical cells arranged in double rows were removed from the trunk of a Pipal tree in July 1909 (Pl. XIII. Fig. 5). The largest nest contained eleven cells. Each cell measured 9 to 10 m.m. long and about 3 m.m. broad. Only one spider was stored in a cell and an egg laid on its abdomen, and in this respect it agreed with *Pseudagenia clypeata* and *Pseudagenia blanda*. Males and females of an undescribed species of *Pseudagenia* emerged from these cells (Pl. XIII, Fig. 6).

In March 1909 I found a big deserted nest of *Sceliphron coromandelicum* constructed in a hollow of a tree. All the cells but one were empty. This one cell did not contain the *Sceliphron* larva or pupa, but was found to be inhabited by the pupæ of a *Pompilid* wasp (*Pseudagenia*). The cell was divided into four smaller cells, and in each was found a pupa encased in a cream coloured thin cocoon. An undescribed species of *Pseudagenia* emerged from these also.

Aporus cotesi, Cam.

These tiny active Pompilid wasps are commonly seen at Pusa during March, each year, on sandy soil by the riverside, chasing small ground spiders. Their nests are probably under ground and are stocked with spiders. On 14th June 1909 I dug out one cocoon of this wasp. On opening this I found the larva 'resting' inside, and in this state it remained for over two months. The cocoon was of a reddish brown colour and club shaped.

Size :—Length 16 m.m. and
Breadth 3·5 m.m. at the widest part.
The wasp emerged on 27th August, 1909.

FAMILY SPHEGIDÆ.

This is a very large family containing nearly 40 Indian genera, representatives of nearly all of which are found at Pusa. The genus *Sceliphron* alone has been studied in detail, but a few observations concerning the habits of other wasps of this family have also been made and these are recorded here.

Notogonia subtessellata (Smith).

I have nothing in particular to add to the habits of this wasp given in "Indian Insect Life," but I may quote here one or two observations from my Note-book dealing with the subject in detail.

Pusa—13th Feb., 1908.

"Noticed *Notogonia subtessellata* ♀ flying on sandy soil, on the left bank of the river. She selected a spot and began digging there. A small hole was dug up in the beginning and then she removed the loose soil: went into the hole a second time, dug further down, and came out again with loose soil. (The anterior legs are turned into a loop to carry the soil out). This soil was heaped up close to the mouth of the hole, but as the heap assumed an appreciable height, she got to the top and demolished it by kicking away the soil by her hind legs, to prevent its falling back into the hole. She must have been digging for about five minutes when, from a hole just close to the one dug out by the wasp, there jumped out a small white immature cricket. The wasp was inside the hole, but she somehow learnt that her prey had escaped; the cricket came to the place where I was standing and hid itself under my glass topped box which was lying on the ground. The wasp also hastily came out of the hole, and finding another hole close by entered into it. I got hold of the cricket and thrust it in the hole behind her. It jumped out again, but was closely pursued by the

wasp. The cricket showed much agility, but was in a moment in the grasp of the wasp. She stung it on the under-side, near the pro-mesosternal suture. As soon as the poison was injected the cricket, which was so active just a minute before, lay motionless, though not dead. The wasp left it and surveyed it probably with a sense of relief and satisfaction. Presently she jumped on its back, and, grasping an antenna, sat as if in a riding posture. She took four or five one-foot flights with the heavy load and ultimately flew away from my sight behind the Tur plants which were growing thick close to the field where I made this observation."

"Another *N. subtessellata* dug out a cricket from its burrow, stung it and carried it to its nest which was situated in sandy soil under ground. Just close to this nest she alighted from the back of the cricket, caught hold of an antenna and entered the nest moving backwards facing the cricket."

Multan City (PUNJAB), 14th April 1908.

"At the foot of a wall there was a hole, in which I noticed *Liris hæmorrhoidalis*, Guér, entering with a big ground cricket. As the wasp is very pretty and not found at Pusa, I was anxious to obtain this specimen. I could not remove the bricks and the plaster from the wall, and the only way to get it, I could think of, was to place my killing tube at the mouth of the hole. After 15 minutes, on looking to my tube I was astonished to find a specimen of *Notogonia subtessellata*, with the desired specimen of *Liris*, in it. Whether the *Notogonia* had been by mere chance to the hole of *Liris*, or there were two separate chambers with a common entrance, or the former had entered into the nest of the latter with a view to steal away the stored crickets or to lay eggs on them, I cannot definitely say. But it is an interesting fact to record."

Pison erythropus, Kohl.

Early in November 1908 I collected some small cylindrical clay cells which were entangled in the cobweb of a spider high up on a tree. The cells were very delicate and broke under the slightest

pressure of the fingers. Both the ends of the cells were rounded and each cell measured about 9 mm. long and 4 mm. broad. On opening up a cell I got about 30 minute spiders and a tiny little larva feeding on them. It was no small wonder to behold so many spiders packed together in so small a compass. The larva when full-grown spun a rather tough dirty brown cocoon, the lower end of which turned darker as the larva deposited excrement at the bottom. Each cocoon measured 8 mm. long and 4 mm. across, cylindrical in shape, with ends rounded. The larva hibernated throughout the winter and on 18th March 1909 several wasps emerged. The hibernating larva, like *Sceliphron* larvæ, lies doubled up inside the cocoon.

On another occasion (in June 1911) I saw these cells constructed close to the white silken cocoon in which spiders enclose their eggs.

In a nest there are from 6 to 12 cells, and in each cell about 36 minute spiders are stored. Taking nine as the average number of cells in a nest it would be necessary for the wasp to paralyse at least 324 spiders, a number which is not easy to secure. It is for this reason that we find the cells of this wasp close to or on the spider webs, so that she may not have to go far away in quest of her prey. The white silken cocoon mentioned above was found to contain only the empty egg shells and the wasp larvæ inside the cells had pupated. It appears that the wasp selected this site for her nest at the time when the eggs were just hatching.

For reasons discussed under *Sceliphron madraspatanum* I do not consider this wasp to be a beneficial one.

Trypoxylon pileatum ♀ (Smith).

This wasp, so far I have seen, very seldom constructs a nest of her own. It generally occupies empty reeds, thatch, dry empty branches of the Ak plant (*Calotropis* sp.) and of the Pipal tree (*Ficus* sp.) which once contained the cells of the green bee *Ceratina viridissima*, Dall. Torr. Once I saw this wasp making a cell in the folds of a newspaper, and this has been observed by the late Col.

Bingham also (*vide* "Fauna of British India, Hymenoptera," Vol. I, p. 223). It always takes advantage of ready-made holes, and natural cavities, which are simply partitioned off into cells by round mud plugs. In very rare cases the female has been observed removing dry soft pithy substance from a dry branch of a tree or of a plant for nesting.

In each cell paralysed spiders are stored, on which the larva feeds. Fig. 5 shows this wasp bringing a spider to her nest in a hollow stem. When full-grown the larva spins a thin brownish cocoon inside which it pupates. The pupal stage lasts for about 12 days. A few days prior to the emergence of the wasp the pupa develops on either side of the three basal abdominal segments white crescentric marks which remain visible for at least two days even after the emergence of the wasp.

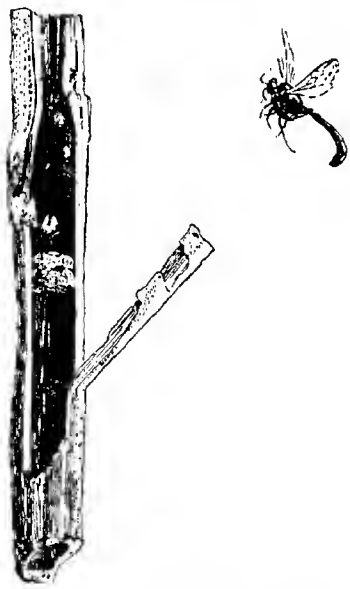


FIG. 5. TRYPOXYLON PILEATUM BRINGING A SPIDER TO HER NEST IN A HOLLOW STEM; THE NEST HAS BEEN OPENED TO SHOW THE CELLS. (I. I. L.)

An undescribed species of this genus, very similar in habits to *T. pileatum*, has been bred here from cells in reed and thatch. The largest number of cells found as yet in a nest of this species has been twelve. The pupæ are encased in thin brownish yellow cocoons which are 7 mm. in length and 2 mm. across.

The spiders stored in both these cases are the web-spinning species. These I understand to be useful to some extent for the reasons discussed under *Sceliphron madraspatanum*. These wasps I consequently class as injurious insects.

Genus Ammophila.

The undernoted species of this Genus are common at Pusa :—

1. *Ammophila basalis*, Smith.
2. *Ammophila nigripes*, Smith.
3. *Ammophila lœvigata*, Smith.

The habits of *Ammophila lœvigata*, Sm., have been described in "Indian Insect Pests," pp. 271-272, and need not be reproduced here. The remaining wasps also behave similarly. These wasps appear each year as early as April and remain active till October, but are commonly met with only during August and September when they are seen hunting caterpillars in the fields. Since these prey upon caterpillars, they are decidedly beneficial insects.

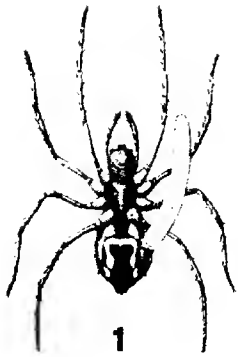
Genus Sceliphron.

Sceliphron madraspatanum (Fabr.).

The female wasp constructs mud nests consisting of 2 to 7 long narrow semi-cylindrical cells, in the corners of houses, in wooden furniture, etc., etc. These cells are stored with spiders, and each cell may contain about 18 spiders or a few more or less.

Length of a cell externally, top to bottom is 27—30 mm. Length of actual cavity inside is 19—20 mm. and width 6 mm.

A cell is raised to the necessary height in the first instance and the mouth above is left unclosed. Next, paralysed spiders are brought in one by one till the required number to be stored is reached. The mouth of the cell is then closed with a mud plug and another cell is started in the same way. Cells, when just completed, show some evidences of skill in architectural design (Pl. XIII, fig. 8), but when the whole nest is finished, mud pellets are thrown over it at random making it look like a mere lump of mud (Fig. 6). Horne says "on one occasion I observed rays of mud round the nest even more exactly imitating a lump of mud thrown with some force. This I hold to evince a most wonderful instinct as they could not be required for strength." (Trans. Zool. Soc. VII, p. 163, 1870). I have also noticed these streaks, but in very rare cases. I think Horne has attributed more than is *Sceliphron's* due. What happens is simply



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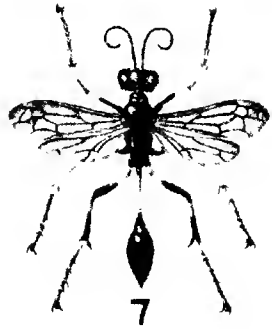

7

SCELIPHRON MADRASPATANUM.

EXPLANATION OF PLATE XII.

Sceliphron madraspatanum.

1. A Spider bearing an egg of the wasp on the ventral side × 8
2. ,, ,, a two days' old wasp larva × 8.
3. Full grown larva, side view × 2.
4. A partly finished nest of the wasp × natural size.
5. Pupa, inside cocoon × 2.
6. Pupa, ventral view × 2.
7. Wasp drawn from a pinned specimen × 2.

this, that if some one is watching the nest from close quarters and the wasp returns in the meanwhile with a mud pellet, instead of alighting directly on the nest she alights some distance away. Being "fearless when engaged in cell building" (to quote Horne's words) she boldly walks up to the nest with the wet mud ball (held between the forelegs and the mouth) touching against the wall. It is thus that the mud rays are traced on the wall converging to the nest from different sides. I am therefore of opinion that the presence of mud streaks is not suggestive of any wonderful instinct, but is the result of mere chance.

FIG. 6. FINISHED NEST OF SCELIPHRON MADRASPATANUM. (FROM A PHOTOGRAPH).

The egg is deposited on the 1st spider brought into a cell and is laid obliquely across its abdomen near the base, in such a way as to enable the young larva to eat into the soft portion of the abdomen (Pl. XII, Fig. 1). Should the egg be laid in a cell and the required number of spiders not stored before dusk, the *Sceliphron* puts a temporary clay covering on the mouth of the cell for the night, and this is taken off the following morning. At night the *Sceliphron* is never seen on or near the nest. Early in the morning or at dusk these wasps can be seen sleeping on the leaves of bushes.

The egg is white, semi-transparent; in shape long, cylindrical with ends rounded. Length is about 3 mm. and breadth 0·8 mm. Before hatching the colour changes to uniform milky white and is opaque. This stage lasts for one to two days.

The larva on hatching remains in exactly the same position and locality as the egg. The only thing which readily distinguishes it from the egg is the prominent constriction separating the head from the rest of the body. In length it is a little more than 4 mm.

and it is white in colour. The body is indistinctly divided into segments of which those in the middle are clearly marked. It commences to feed on that part of the abdomen where it finds its mandibles in contact with the skin of the spider. Finishing this spider it attacks the next one above it. Thus it works its way upwards devouring one after another all the spiders stored in a cell (Fig. 7).*

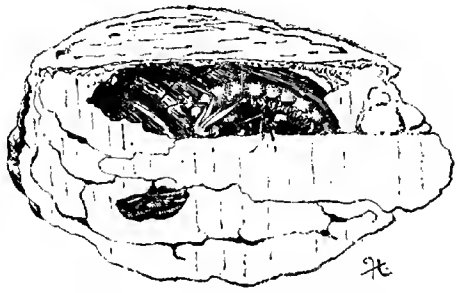

FIG. 7. SCELIPHRON MADRASPATANUM NEST REMOVED FROM A CORNER, AND SEEN FROM BEHIND; LARVA FEEDING ON A SPIDER. (I. I. L.)

The colour of the whole body undergoes a gradual change. First it becomes dirty white, then changes by degrees to gray, excepting the head, one or two succeeding segments and one or two terminal segments, which are all yellow.

In size it increases at the rate given below :- -

1*st* day length 4·5 mm....	White; indistinct ridges on the body.
2*nd* day „ 5· mm. ...	Much broader than before. Head and margin of the body white, rest grayish.
Afternoon.	Body more gray.
3*rd* day length 6· mm. ...	Colour same; integument transparent.
4*th* day „ 9· mm. ..	Head and apical segments yellow, margin dirty white, rest of the body gray; very much broader than before.
Afternoon.	length 10·5 mm.
5*th* day length about ...	... 12 mm.
6*th* day „ ...	.. 13·8 mm.
7*th* day „ ...	... 14 mm. full grown.

* NOTE.—It is for this reason that we always find a larva of this wasp head upwards in a cell.

The development is rather rapid after the 3rd or 4th day and on the 5th or 6th day it attains the length of 12 mm. and, when full-grown (in a week's time), it measures about 14 mm. long and 3 mm. broad in its widest part.

Full-grown larva.—Its general colour at this stage is gray ; head yellowish, apical two segments yellow and mandibles ferruginous. The integument is soft and from above semi-transparent, and through it are visible white particles of fat moving backwards and forwards. The body is broadest in the middle, and narrows both anteriorly and posteriorly. It is margined on both sides ; margin very protuberant, yellowish in colour. On each side of the body there are 10 small circular spiracles of ⊙ shape. The body is divided into 14 segments, the middle ones are distinct and deeply cut. The segment representing the prothorax has four or five fleshy triangular (more or less conical) tubercles. The head is usually doubled below the thorax. (Pl. XII, Fig. 3.)

It has been observed that the larva moults several times before it attains full length, but the exact number of moults it passes through could not be ascertained, for the larva is in the habit of eating away the skin as soon as it is loosened, leaving behind no trace of the moult.

When full-grown the larva begins to spin a cocoon of light yellow silken threads which turn brown afterwards : the threads are so thickly and closely laid that the cocoon looks as if made of brown papery material. The cocoon is long oval, narrow towards the bottom ; the top is rounded, and it is as broad there as in the middle. Length is about 19 mm. (Pl. XII. Fig. 5.) When the cocoon is spun, the larva pushes out through the anal tube a black mass of excreta, which is deposited at the bottom of the cocoon. (In empty cocoons obtained from old nests it is found as a black hard substance at the bottom. In case part of the excreta remains sticking in the terminal segment of the body, and is not completely discharged, the larva is sure to die either before or after pupation.) The colour of the larva is changed to yellow, the body is divided into deeply cut segments with protuberant margins, which on account

of the deeply marked divisions have the appearance of fleshy tubercles on the sides. The larva becomes more compact, decreases in length, but becomes broader. The length is about 10 mm., breadth about 4 mm. It loses its activity and remains motionless inside the cocoon for a period which extends over 3 to 6 days in summer and early autumn. This stage I term the "resting stage."

Pupa.—The 6th segment of the body, reckoned from and including the head, becomes narrow prior to casting off the larval skin which may take place 11 to 15 days after hatching. This cast skin in some cases remains sticking in a rolled-up state to the apex of the abdomen. All the limbs of the perfect wasp appear with the shedding of the larval skin; the antennæ, mouth-parts and legs are symmetrically folded on the ventral surface (Plate XII, Fig. 6) and this appears to be a constant feature with all Hymenopterous insects (Aculeates).

In a fresh pupa the abdomen is not connected with the thorax by a narrow stalk but is joined on broadly, as we find in Sessiliventres (Adults); consequently the length of the fresh pupa is short (about 10 mm.). The region between the abdomen and thorax begins to be narrowed gradually, and after two days the petiole assumes its ultimate dimensions and the pupa attains the length of about 14 mm. The pupa is of a whitish pale colour, the mouth parts excepting mandibles, antennal joints, tarsal joints and petiole being white. A gradual change in the colouration of the pupa sets in and is first exhibited by the eyes, which assume a pinkish tinge 2 or 3 days after pupation. This colour changes to dark red, then to slate colour and finally to black. The colour of the thorax also undergoes a gradual change. On the 7th day of pupation the head and thorax down to the apex of the median segment and legs in parts become black excepting a medially interrupted line on the prothorax and a line on the scutellum which are yellow. On the 8th day the abdomen also becomes black; the whitish yellow or pale colour of the remaining limbs of the pupa turns yellow on the 11th day. Wings up to this stage remain undeveloped. In their place are seen thick pads of delicate skin covering the meso- and metapleuræ.

The pupa is covered by a thin transparent pellicle which is cast off on the 11th or 13th day after pupation and the perfect wasp with long graceful wings emerges. The wings are delicate but get harder as they dry. The wasp pierces the brown cocoon in which it is encased and then removes the mud plug put on the top of the cell. A neat circular hole is formed and the wasp escapes through it.

Thus the whole life cycle occupies about four weeks.

Egg stage ...	... ...	From 1 to 2 days.
Larval ,, (including "resting stage")		,, 11 to 15 ,,
Pupal stage ...	... ...	,, 11 to 13 ,,
Total	..	From 23 to 30 days.

Nests for the last brood are constructed in the middle of October, the winter and the early part of spring being passed in hibernation, which takes place in the 'resting stage.' Wasps emerge towards the end of the following March, and the cycle is commenced again. Thus beginning with April up to the middle of October this wasp runs through seven complete broods.

In the middle of October 1910, I collected a nest containing about 10 cells from which four wasps and one Ichneumon parasite emerged in November 1910. On opening the remaining cells larvae were found hibernating in them. Wasps from these emerged in the last week of March 1911. During four years this was the only instance I came across in which half the inmates of a nest emerged at one time and the remaining half after five months.

Enemies.—The following parasites have been reared from the cells of this species :—

I.	Chrysid wasp	..	*Chrysis* sp. near *fuscipennis*.
II.	Tachinid flies	..	Species undetermined.
III.	Bombyliid flies	..	*Hyperalonia sphynx* and *Argyramœba distigma*.
IV.	Mutillid ant	..	*Mutilla* sp. near '*oglana*.'
V.	Mordellid beetle	..	Species undetermined.
VI.	Ichneumon fly	..	
VII.	Strepsiptera	..	

I. Chrysid Parasite.

On opening up a cell parasitised by No. 1, we get some dried spiders and below them *at the bottom of the cell* a larva or a pupa covered by a brownish tough cocoon.

The Chrysid larva attacks the *Sceliphron* larva when the latter is a few days old. On finishing it up, it spins a cocoon inside which it rests for some days prior to pupating. On casting off the larval skin the pupa shows all the limbs of the perfect wasp and is of a pale yellow colour. Then gradual changes in the colouration of the pupa occur, as described above in the case of *S. madraspatanum*. The eyes show signs of change first. They become pinkish and this colour passing through successive intermediate stages of changes, turns ultimately black. The thorax and abdomen then develop some sordid pinkishness which changes to a greenish tinge. Day after day the insect grows more and more green, golden green and blue in parts till the thin pellicle covering the pupa is gradually rolled up, and the perfect wasp piercing the cocoon emerges through the top of the cell.

It will be interesting to note that Chrysid larvæ go into hibernation at just about the same time as the *Sceliphron* larvæ do, and the time of emergence of both is also nearly the same.

II. Tachinid Flies.

In the cell parasitised by No. 2 we find only dried limbs of spiders. There are also found either dirty white maggots tapering anteriorly or reddish brown cylindrical puparia which may be as many as six in a cell.

So far I have not succeeded in getting eggs of the Tachinid fly in a cell, nor have I personally observed how these are laid inside it. On more than one occasion, however, I have found very young maggots in cells which had just been closed.

These maggots are found generally (in freshly constructed cells) on the abdomen of that spider which lies at the bottom of a cell, and on which the wasp lays her egg. A freshly hatched maggot measures about 1 mm. in length, is dirty white, and tapers anteriorly, and is

truncate posteriorly. Gradually it increases in length and changes its colour day after day, till it is full-grown (9 mm. or more) and the colour becomes once again dirty white, after having gone through a series of changes, *e.g.*, dirty white for first three days, dirty black on 4th, on 5th dirty brown, and then dirty rusty brown from above and sides white; on the sixth day whitishness goes on increasing and brownish colour decreases proportionately, till on the 8th day whitishness spreads all over the body of the maggot.

Usually on the 9th day after hatching pupation takes place. The maggot becomes compact and decreases in length, the tapering end is drawn in telescopically and the whole long thick tapering mass turns into a small cylinder (a little curved inwards) with ends rounded, of pale testaceous colour (which gradually changes to dark reddish brown afterwards), very smooth and shining. It is 5·5 mm. long, 2·2 to 3 mm. broad. This is known as the "puparium" and it encloses the true pupa.

The pupal stage lasts from 10 to 12 days. The Tachinid fly does not possess the strong mandibles of a wasp to cut open a passage through the puparium, but Nature has supplied this want with what is known as a "Ptilinum." This is an inflatable balloon-like organ capable of being thrust out through a frontal suture just above the base of the antennæ. When the fly is about to emerge from the pupa case, this balloon expands and pushes off the end of the puparium, thus making an exit for the fly to escape through. The fly on coming out is only able to walk or hop, it cannot fly, for the wings are not expanded. When the Ptilinum resumes its original position inside the suture some moisture inwardly reaches the wing pad, and the wings, on being relaxed, open, if not otherwise damaged.

I collected a nest of *Sceliphron madraspatanum* in the middle of October 1908 and kept it under observation in a glass-topped box. Wasps from this emerged on 28th, 29th and 30th March 1909. Still there were one or two cells out of which nothing had emerged. It was surmised that either the wasp larvæ had gone bad inside the cells or they had been parasitised. But Chrysid parasites had come out long ago, Bombyliids were still emerging (June 1909), though

not from *Sceliphron* yet from *Pseudagenia* cells. I was surprised, however, to find a Tachinid fly emerging from the nest on 4th June 1909. This points to an important conclusion that Tachinids (parasitic in the cells of *Sceliphron madraspatanum*) hibernate during the whole of winter, spring, and a part of the hot weather also.

One more interesting point in this connection. I should better quote it *verbatim* from my observation-book.

"Last year (1908) when as many as half a dozen puparia were obtained from a single cell of *Sceliphron madraspatanum*, I wondered how so many maggots could be nourished on one small wasp larva. This year (1909), on 15th June, I removed a nest consisting of three cells; the third cell was not yet closed. On the abdomen of a spider found at the bottom of one of these cells I got six Tachinid maggots just at the place where the wasp egg is ordinarily found. No trace, however, was left of the egg there. It must have been consumed by the maggots which having finished it were now eating into the abdomen of the spider. When this spider was finished I gave them another and thus they consumed 12 spiders one after another before they pupated. This clears the whole point. The Tachinid maggots live chiefly on the spiders placed in the *Sceliphron* cells. The Tachinid, therefore, is a serious enemy of *Sceliphron*, for it proves destructive to its larvæ in two ways, either by directly eating it up or by starving it, should it escape anyhow.

III. *Hyperalonia sphyræ*.

I have not yet been able to secure an egg or a larva of this fly. Only pupæ were found in the two nests from which were bred these flies. Consequently I do not know anything about the egg-laying habit of this fly, nor can I give a description of its larva.

Another *Hyperalonia* sp. (allied to the above species) has been found to be parasitic on *Pseudagenia blanda*, a Pompilid wasp. Since both the *Hyperalonias* resemble one another very much in the adult stage, it is quite probable that their larvæ also agree. A *Hyperalonia* larva parasitic on *Pseudagenia* has been described in its proper place (p. 195).

Pupa.—Length 11·5 mm. The general colour is dirty yellow. It has a brownish yellow covering (of harder skin) over the head and the following two segments of body (dorsal) and three segments (ventral). This covering bears eight sharp spines arranged in three rows :

(*a*) Two in the 1st row (on the ventral side).

(*b*) Four in the 2nd row (in front).

(*c*) Two in the 3rd row (in front, just above those of the 2nd row).

On all the segments above there are minuter but sharper spines pointing backwards, and their apex slightly curved upwards. These spines are longer and finer on segments 4, 5 and 6 (reckoned from headside) than on any other. The last segment also has two spines pointing backwards and curved slightly upwards. There are long rather stiff hairs on the body (fig. 8).

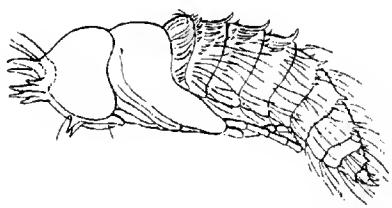

Fig. 8. Pupa of Hyperalonia sphynx showing spines.

The pupa is broadest in the middle, gradually narrowing posteriorly. It is found inside the brown cocoon in which the full-grown wasp larva rests before pupating, inside this cocoon nothing is left of the wasp larva excepting the hardened black excrement discharged by the full-grown larva prior to abandoning its active life.

When the Bombylid fly is about to emerge the pupa makes a hole in the mud nest by means of the sharp spines with which it is provided anteriorly, wriggles out a little, and fixes itself there by means of the sharp and backwardly pointing spines with which its

body is furnished. The pupa skin bursts and the fly emerges, leaving behind the empty pupa skin projecting out from the hole (Fig. 9).

FIG. 9. PUPA SKINS OF HYPERALONIA SPHYNX IN NEST OF SCELIPHRON MADRASPATANUM ×2 (I. I. L.)

Argyramœba distigma.—This fly was bred once in August 1908, and again in March 1909 from the hibernating larvæ of *Sceliphron madraspatanum*. Its mode of emergence from the nest is exactly the same as described above in the case of *Hyperalonia*.

IV. *Mutillid Wasp, Stenomutilla oglana*, Cam.

These wasps were reared from the cells of *S. madraspatanum* twice (*i*) in August 1908 and (*ii*) in September and October 1908. Unfortunately only males emerged on both occasions.

V. From a nest collected in September 1909 from a hole in the trunk of an old Pipal (*Ficus religiosa*) tree was bred a Mordellid beetle (species undetermined).

VI. An Ichneumon exactly similar to the species bred on *Pseudagenia clypeata* Bingh. was reared from the cells collected in October 1910.

VII. At Pusa up till 1910 *Polistes hebræus*, F., alone had been found infested with Strepsiptera, but in March 1910 when *Sceliphron* wasps emerged after completing their hibernation period they

also were found to carry in their abdomen male pupæ of individuals belonging to this order. Several attempts were made to rear them to adults but with no good results. The difficulty is to keep the *Sceliphron* living in confinement for a sufficiently long time to enable the parasites to emerge. The wasp dies soon and the parasite, failing to get the requisite amount of moisture from the dead body, follows suit.

Economic.—An insect may be :—

I. Useful.
II. Beneficial.
III. Injurious.

I. It is useful if it produces a thing which is of some economic value ; *e.g.*, Silkworms, Lac Insects, etc.

II. It is beneficial if it destroys our insect enemies, *e.g.*, Parasites, Predaceous insects, etc.

III. It is injurious if it destroys things or insects useful or beneficial to us, *e.g.*—(*a*) Caterpillars damaging cultivated crops : (*b*) Caterpillars of Eublemma which feed on *Tachardia lacca*, etc.

Let us examine *Sceliphron madraspatanum* to ascertain to which of the above noted three classes it belongs. Does it produce anything which is of any economic utility ? No : it is, therefore, not a useful insect. What does it destroy ? Spiders. Are spiders our friends or enemies ? I do not pretend to know much or anything about Arachnids. It is, therefore, a very difficult task for me to definitely put down whether the spiders found in the cell of *Sceliphron madraspatanum* are beneficial or injurious to us from an economic standpoint. Casual observations and daily experience tell us that spiders are generally predaceous on insects. On the one hand, we find the common flies, which are a nuisance in our houses during hot weather, and small moths, caterpillars, which damage our crops considerably, entangled in the spiders' webs ; on the other hand, we witness small Hymenoptera and Tachinid parasites struggling for life in the clutches of spiders. In one case we find our enemies destroyed, in the other our friends. It is, therefore, a still more difficult

question to decide whether spiders do greater good by lessening the number of flies and other insects injurious to us, or are productive of greater harm by killing our friends. On a satisfactory answer to this question depends the solution of the main problem. If it is found that spiders do us greater harm than good, the *Sceliphron* is decidedly then a beneficial wasp. But one, who is well conversant with the habits of spiders, can alone opine on this matter definitely and reliably.

What commonsense tells us is that big predaceous beetles, Reduviid bugs, wasps, parasites and dragon flies, etc., are never seen in a spider web, for their weight alone in some cases is sufficient to ruin the whole elaborate construction. It is, therefore, as a rule, only small insects which fall a prey to these spiders. Amongst them may be counted, moths, minute Hymenoptera, Diptera, etc. Of these, moths are generally injurious, Hymenoptera generally beneficial, Diptera both beneficial and injurious. Again, parasites are never so abundant as other insects; consequently out of the insects found in spider-webs a comparatively very much larger number should be of insects other than parasites; and daily experience confirms this conclusion. Generally speaking, therefore, spiders kill insects which are injurious to us, and are thus 'beneficial.' *Sceliphron* wasps which store spiders in their nests are, therefore, 'Injurious insects.'

General.—A strange belief is current in the Punjab regarding this wasp. People there think that it possesses the miraculous power of imparting its shape and colour to other 'insects.' Ignorance of Entomology justifies them in their belief. They say, what they occasionally see. They notice a *yellow and black wasp* bringing spiders and storing them up in mud cells which are closed afterwards. After the lapse of a month or so, they find more than one yellow and black wasp emerging out of the same mud nest. They do not know exactly what happens inside the cells. They only think that spiders having passed some weeks in confinement in the mud nest undergo a complete change in form and colour, under the influence of the wasp.

I cannot help quoting from my note-book one observation which is not very complimentary to this intellectual wasp.

"I was once watching a *Sceliphron madraspatanum* constructing a nest against a window. One cell was completed and another started by its side: spiders were stored in it and the final plug to close the top opening was put in. The wasp then commenced putting mud pellets on the cells: during her absence I scraped off the two cells. The wasp returned as usual with mud and placed it on the traces of the cells left behind on the window. The wasp continued throwing mud pellets with the usual earnestness till the portion once occupied by the cells was completely covered over with mud.

Did the *Sceliphron's* eyes deceive her or does she blindly follow a 'set routine' from the raising of the cell to the throwing of the mud pellets. I cannot venture to guess? However, it is an observation worth recording."

On 2nd April 1911, I removed from a wall a nest of this wasp, all the cells of which contained hibernating larvæ, excepting one which had freshly paralysed spiders stored in it. This cell was placed at right angles to the remaining ones and was evidently constructed only a few days prior to my removing the nest. On the spider at the bottom of the cell was found a two days' old larva. Naturally the colour of the mud used in the construction of both, the nest and the cell, could not be the same. That of the former was lighter than that of the latter. But the difference in colour was noticeable only from the inside, *i.e.*, the side which was against the wall. Externally the cell appeared to be a part of the same nest, and no one could imagine that it was added some months after the nest was constructed, for the wasp had put mud pellets not only on her own cell but also on the nest. Different conclusions can be drawn from this incidence according as we may view the wasp's action. We may take her to be endowed with "wonderful instinct" thinking that she took special care to blend her cell with the nest so skilfully as to deceive human eyes, or we may call her a stupid wasp considering that she simply wasted her energy in throwing mud pellets on a

nest which was after all not her own, and to which she had added only a single cell.

Empty cells in the nest of *Sceliphron madraspatanum* have been observed on several occasions to be inhabited by the larvæ of *Sceliphron violaceum*, *Megachile lanata*, and *Odynerus punctum*.

I can fully endorse Horne's observation that no bird attacks this wasp: stomachs of hundreds of birds were opened and examined in our laboratory, but the body of this wasp was never found in any of them.

Sceliphron coromandelicum (Lepel).

Sceliphron coromandelicum is larger in size than *Sceliphron madraspatanum* and consequently the mud cells of the former are longer and wider than those of the latter. The egg, larva, and pupa of *coromandelicum* are also proportionately larger in size than those of *madraspatanum*, and even the spiders stored by the former in its cells are bigger in size than those found in the cells of the latter. The following measurements will clearly show this point:—

	S. madraspatanum.	S. coromandelicum.
Length of cell externally	27 to 30 mm.	30 to 33 mm.
Width across	6 mm.	9 mm.
Egg	about 3 mm. long	about 3·4 to 4 mm. long.
Full-grown larva	about 14 mm.	about 18 to 19 mm.
Pupa ... ,, ...	13 to 14 mm.	about 17 to 18 mm.

Sites selected by this species for nest-making are usually doors, windows, walls, and hollows of trees. It appears that this wasp takes great pains in selecting a really good and well protected site for this purpose. I have seen scores of these nests inside hollows of trees but never come across a single instance in which the nest was built in a place exposed to rain or moisture. With a peculiar interest I used to watch such trees as had in them several sheltered recesses and was always struck with admiration to notice all the recesses watered, after a heavy shower of rain, excepting those occupied by the nests of this wasp. A single nest may contain from one to eighteen or more cells, and when finished it is completely

covered over with mud. Sceliphron's throwing mud pellets on a nest is always a sure indication of the fact that no more cells are to be added.

The life-history of this wasp is exactly similar to that of *Sceliphron madraspatanum*, and need not be repeated here *in extenso*. Briefly it is as follows :—

The egg is laid on the first spider brought into the cell. The egg is 3·4 to 4 mm. long and invariably hatches on the following day. The young larva on consuming the spider on which it finds itself attacks the next spider above it, and this is continued till all the spiders stored by the mother wasp are exhausted in a week's time. The larva is full-grown then and measures about 18 to 19 mm. It spins a cocoon within which it rests from 3 to 5 days prior to pupation. On the 12th day after pupation the thin pellicle covering the pupa is cast and the wasp emerges. The period from egg to perfect wasp is about 4 weeks.

Enemies.—From the cells of this species have been bred the following parasites :—

(*i*) Chrysid wasps.

(1) *Chrysis fuscipennis.*

(2) *Chrysis sp.*

(*ii*) Tachinid flies.

(Species undetermined.)

(*iii*) Strepsiptera.

It is not necessary to repeat here what has already been said respecting the above-mentioned parasites under *Sceliphron madraspatanum*. But one interesting point is worth recording.

On 9th August 1908 I scraped off a *coromandelicum* nest, consisting of four cells. It was found on examination that from two of the cells perfect wasps had already flown out, and that the remaining two were still closed. The "lids" of these cells were removed, and big, partly dried spiders were seen inside, a fact which assured

me of the presence of some parasites in them. I found at the bottom of each cell, covered by a brown cocoon, a full-grown Chrysid larva. In due course of time from one cell emerged (on 20th August 1908), a Chrysid wasp, but the pupa in the other did not even reach the stage of changing colour. Seven days afterwards (on 27th August 1908) a Chalcid (*Prelampus sp. ?*) came out, piercing the cocoon from above. On examining the parasitised pupa of the Chrysid wasp I found a thin brownish yellow cocoon of the Chalcid attached to the median segment of the wasp pupa. This is an example of the phenomenon known as "Hyperparasitism."

Again, in October 1908, I took a large nest of this species consisting of 12 cells from a hollow in an old tree. Almost all the cells were found opened, the perfect wasps had long emerged; still there were a few cells closed. It seemed evident either that there were parasites inside them or that something had gone wrong with the larvæ or pupæ inside. I opened these cells one after another and found in some dried, in others rotten larvæ or pupæ, but from one I obtained a green *Chalcid* parasite (dried up, of course), similar to one I had already reared from the cells of this species (on 27th August 1908). This parasite bears a striking resemblance to a Chrysid wasp and can only be distinguished from it after a close and careful examination.

The life history of the Tachinid parasites has been dealt with previously, but it is an interesting point how the flies emerge from the clay cells of this wasp. Tachinid flies are not provided with strong mandibles of a wasp to cut a passage through the hard walls of a mud cell. Consequently, the emergence of these flies from clay cells was a question worth studying. I made several observations on this subject, which I need not detail here at any length. I simply note down the conclusions arrived at.

As described elsewhere (under *S. madraspatanum*) Tachinid maggots taper towards the head end. This end is naturally very sharp. When these maggots are three days old, they display a voracious appetite and in search of food knock about inside clay cells (or glass crucibles when taken out of clay cells for observa-

tion sake), thrusting the tapering sharp end into the walls. These gentle but persistent strokes of the tapering end work like a drill, and in the case of the common wall of the two adjoining cells, one or two holes may be bored through.

Next, consider the size and position of these holes. (1) Suppose the holes are small (smaller compared to the rotundity of the maggots) and bored by nearly full-grown maggots, rather high up in a cell; the maggots in such a case cannot get into the next cell. They will pupate, therefore, in their own cell, and, in due course, flies will emerge. If the adjoining cell be empty, as generally is the case (the perfect wasp having flown out), the Tachinid flies will get into it through the 'communicating door' (*i.e.*, holes bored in the common wall in the maggot stage) and escape through the passage cut open by the wasp. If not empty, it must* contain a wasp pupa in a very advanced stage, nearly filling the whole of the cell. Flies will in that case remain in their own cell till the time the perfect wasp emerges, leaving a free passage behind for the flies to get out. In case the flies are required to wait longer than a couple of days, they invariably perish inside their cells: and it is due to this fact, therefore, that we sometimes find dead and dried specimens of these flies on breaking up some mud nests. (2) Suppose the holes made are so big and so situated as to admit of the maggots sliding through into the adjoining cell. Maggots will decidedly in such a case get into the next cell and eat up the wasp larva or pupa. Should it not satiate them they would work their way into the next adjoining cell till their hunger is appeased. Their emergence will, of course, depend on the circumstances detailed above.†

Economic.—I have nothing more to add to what has been said in this connection under *Sceliphron madraspatanum*. The same remarks apply here also.

General.—1. Empty nests of this wasp have been found to be inhabited by *Pompilid* wasps—*Pseudagenia* sp. Observations on this subject appear under *Pseudagenia*.

* Because these Tachinids and Sceliphrons take nearly the same time to develop from the egg to imago.

† In this connection see also p. 238.

2. A finished nest of this species is very much like that of *Sceliphron madraspatanum*, excepting that the nest of the former is bigger in size than that of the latter. By a 'finished nest' I mean a nest to which no more cells are to be added, and one which is completely covered over with mud.

Nests of these two species in the unfinished state are quite distinct and can be distinguished from each other without much difficulty. Beautiful ridges are seen across the cells of both the species. These run more or less obliquely (only slightly curved downwards) in the case of *coromandelicum*, but the curve runs into an angle near the middle in the case of *madraspatanum* (Plate XIII, Figs. 7 & 8).*

Some time in October 1908, I collected beautiful clay cells (all arranged in one line), which were decidedly of some *Sceliphron* species; with the aid of the above-mentioned test, I could put them down as those of *Sceliphron coromandelicum*. In the previous April I had collected a nest, containing 18 cells, all arranged in one line, but unfortunately all the cells were empty; I therefore could not find out definitely what species had constructed the cells. The cells collected in October were exactly similar in general shape and structure to those found in April, and since the former were yet inhabited there was every hope of knowing the species on the emergence of the perfect wasps from these cells. I had to wait till 2nd April 1909, when *Sceliphron coromandelicum* began to emerge one by one from the cells. Now *Sceliphron coromandelicum* never places all her cells in one line. No doubt at first she makes three, four or five cells in a line, and then two, three or four cells (as the case may be), are placed over them, and then another layer of one or two cells succeeds till at last the whole construction is covered over with mud: but as many as eighteen cells are never placed in one line; as found in the case of the nest obtained in April 1908. *Coromandelicum* commences nest-making in April each year, the empty nest of April 1908 therefore must have been constructed in the middle of the previous October, when the nest-making for the hibernating brood is started.

* NOTE.—This holds good when the cells are viewed from the front and not from the side.

Thus I got two nests, agreeing with each other in general shape, structure and the arrangement of cells, and which were both constructed in the same month of different years. From these facts it may be concluded that the cells of *Sceliphron coromandelicum*, built late in autumn, are *sometimes* (not always) placed in the above-mentioned way, *i.e.*, all in one line.

I cannot assert this point with any force till I secure more such nests, either late in autumn or any time from winter to the advent of the ensuing spring.

Sceliphron bilineatum (Smith).

This wasp, until 1908, was recorded from Western India alone, but in that year was obtained from Pusa, in the North-East part of India.

In general appearance and colour it looks very much like the common mud-dauber, *Sceliphron madraspatanum*, and especially when in flight it is not easy to distinguish one from the other.

S. bilineatum has more yellow colour on the body than *madraspatanum*. The sides of the median segment and a conspicuous spot on the segment succeeding the petiole are yellow in the former, but black in the latter.

Both construct mud cells and store spiders in them, but in the nest-making habit they differ widely. The cell of *madraspatanum* is semi-cylindrical, while that of *bilineatum* is long, oval, being broadest in the middle (Fig. 10). In the case of the former it is entirely fixed from top to bottom against a wall, while in that of the latter only the bottom is fixed, and the rest of it raised at an acute angle. The former constructs cells in juxtaposition and completely covers them all afterwards with mud; the latter erects

Fig. 10.—Sceliphron bilineatum cell. (I. L.

them singly and finishes them by filling up furrows between the ridges on the surface of the cells with mud and smoothing the whole cell from outside as a mason does a wall with a trowel (Fig. 10*a*).

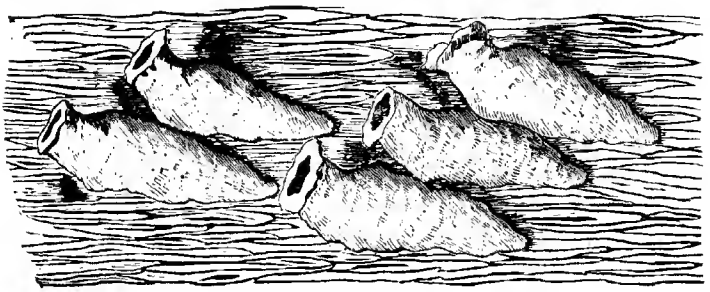

Fig. 10*a*.—Sceliphron bilineatum cells on the top of a bookshelf.

The full-grown larvæ of both spin brown cocoons in which they pupate, but the cocoon of *bilineatum* is lighter in colour and more delicate than that of *madraspatanum*.

With the few exceptions mentioned above *Sceliphron bilineatum* behaves in other respects exactly in the same way as *S. madraspatanum*.

The egg is laid on the first spider brought into a cell; the larva on hatching commences to feed on the spiders stored by the mother wasp; when full-grown it spins a cocoon in which it pupates. With the discharge of excrement (in the cocoon) the larva loses its active life and then follows a period of rest. The larval skin is cast off and a whitish pale pupa having all the limbs of the perfect wasp appears. Gradual changes in the colouration of the pupa then set in, till the colour of the perfect wasp is assumed. The thin pellicle covering the pupa is shed in due course of time, and the perfect wasp (Fig. 11) emerges through an opening made at the top of the cell.

Fig. 11. Sceliphron bilineatum. (L. L.)

The life cycle of this species also is completed in about the same time, *i.e.*, four weeks. Another point of interest in this species which we find in *madraspatanum* and *coro-*

mandelicum also, is that the mother wasp always constructs a cell, the capacity of which is just sufficient to hold that number of spiders which is necessary for the full growth of the larva; its length is always a little more than the length of the cocoon to be spun by the full-grown larva. The full-grown larva, in turn, spins a cocoon which is just a little longer than the would-be mature pupa, plus the length of excrement to be deposited at the bottom of the cocoon. The undernoted measurements will clear this point—

Length of a cell is about	... ...	24 mm.
,, ,, cocoon is about	... ...	20 mm.
,, ,, pupa is about	... ...	15 mm.
,, ,, excrement is about	... ...	3 mm.

Enemies.—Two parasites have been reared from the cells of this species.

(*i*). Chrysid (*Chrysis* sp.).

(*ii*). Tachinid flies (Species undetermined).

I have nothing more to add here to what has already been said concerning the above parasites under *Sceliphron madraspatanum* and *S. coromandelicum*; excepting the following observation which seems necessary.

Since the cells of this species are constructed singly, and there is no superfluous quantity of mud thrown over them to disguise their shape, the walls of these cells are very thin. Consequently the holes bored by the full-grown Tachinid maggots into the sides of the cells serve as so many openings for the flies to escape through.

Sceliphron violaceum (Fabr.).

Wasps of this species are very pretty, and can be readily distinguished from other species belonging to this genus by their conspicuous cobalt-blue colour.

The female does not construct mud cells as do other species of this genus, but always takes advantage of ready-made holes in

which she stores spiders and lays eggs. These holes are subsequently closed with not exactly mud, but mud mixed with mortar and lime.

In all odd and queer holes, such as in walls, doors, windows, bedsteads, bamboos, barrels of rifles, etc., nests of this species are to be seen. In short, wherever she finds an empty convenient hole she utilizes that for her nest. Once I found a cell in the central cylindrical aperture of a common wooden bobbin. At another time from a long deserted nest of *Sceliphron madraspatanum* I got two pupæ of this wasp. I was puzzled a little in the beginning, but in the queer nesting habit of this wasp (of occupying empty holes) I found the solution. A few days later I actually saw a *Sceliphron violaceum* entering into an empty cell in the nest of *Sceliphron madraspatanum*. But the question of *Sceliphron violaceum* occupying empty cells in *Sceliphron madraspatanum* nest was definitely decided when I observed that :—

* "From a *Sceliphron madraspatanum* nest which was long under my observation, all the wasps had emerged, and as this nest consisted of three cells there were three neat circular holes visible on the top of the nest. On my going over one day to the place where the nest was situated I was astonished to find only two holes left; the third one was closed. I removed just a little mud (rather plaster of clay, mortar and lime) from that corner of the nest where the third opened cell was located. From below came to view the top of a dark brown cocoon. I scraped off the nest from the wall and gently opened up this cell. To my great satisfaction I found the lower part of an empty *madraspatanum* cocoon at the bottom of the cell and just above it a dark brown cocoon enclosing a *violaceum* full-grown larva."†

From this cocoon emerged a *Sceliphron violaceum* on 10th September 1908.

* This is quoted *verbatim* from my observation book.

† The cocoon spun by a full-grown *violaceum* larva is smaller in size than that of the *madraspatanum* larva.

Horne records some observations regarding this species under the name of *Pelopœus bengalensis* in the Trans. Zool. Society VII (1870), p. 163. The sketch (Pl. XXI, Fig. 2) which accompanies his account appears to me to be the nest of *Sceliphron madraspatanum* rather than that of this species. He says that "the cells are placed side by side in great numbers, say twelve or fourteen, and so well covered over with mud as to be almost unobservable": but at Pusa I have never seen this wasp constructing an entire separate nest. All that she does in the way of construction is the putting on of 'caps' over deserted or empty cells of other mud-nest-making wasps which are appropriated by her. It is very unlikely that this wasp should have an altogether different nesting habit outside Pusa. There are only two possibilities: either that Horne collected an appropriated nest of *Sceliphron madraspatanum* and on the emergence of his *bengalensis* from the cells mistook the nest as belonging to the latter species or that the wasp has reformed and learnt to be more economical since the time of Horne's observations over 40 years ago.

This habit in some insects of appropriating empty or deserted nests or cells of other wasps always leads to faulty conclusions. In the first place, nests are associated with insects which never constructed them. Secondly, when the nests are known to belong to a species other than the one which has emerged from the cells, the latter is by mistake considered to be parasitic on the former. I remember an instance of this sort of mistake. A student in our laboratory once brought to me examples of *Megachile lanata* (F.), which he asserted were parasitic on *Eumenes conica* (F.), solely on the ground that he reared them from the cells of the latter. Needless to say that it was a clear case of appropriation of empty cells.

Besides *Sceliphron violaceum* the following have been reared by me from nests which originally belonged to other wasps:

Insects bred.	Nests from which bred.
1. *Pseudagrion clypeata*, Emgn. ...	*Sceliphron coromandelicum* (F).
2. *Pseudagenia* sp. (unidentified, probably new) ...	" *madraspatanum* (F).
3. *Megachile lanata* (F.) ...	*Eumenes conica* (F).
4. *Odynerus punctum*	*Sceliphron madraspatanum* (F).

It may be pointed out here that while *Sceliphron violaceum* (F) simply 'caps' the cells, the *Pseudagenia* spp. and *Megachile* (referred to above) make their own cells inside the cavities. The *Pseudagenia* sp. had made four cells inside a single cell of *Sceliphron madraspatanum* (F).

Genus Sphex.

Sphex lobatus, F.

This is one of the commonest wasps found at Pusa. Its large size, charming metallic green colour with golden rosy tints, and graceful flight at once distinguish it from other wasps.

The female wasp (Fig. 12) is generally seen digging up cricket-burrows in fields and meadows from April to August. The cricket is driven out of the burrow, caught, stung and paralysed. It is then removed by the wasp to her nest, but what follows has not been observed. Probably an egg is laid, and the larva feeds on it. When the whole supply of crickets is consumed, the larva pupates and in due course of time the perfect wasp emerges.

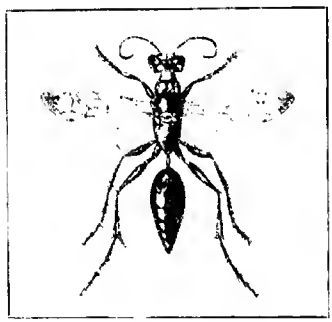

Fig. 12.—Sphex lobatus. (I. I. L.)

Economic.—This wasp preys upon one particular species of Gryllid—*Brachytrypes achatinus*, Stoll., which is a pest of Lucerne, Indigo and Tobacco in Bihar. It is therefore certainly a beneficial insect inasmuch as it checks the spread of an injurious one.

In Bengal ladies make a charming use of the delightfully brilliant skin of this wasp. Circular discs neatly cut out of its body are fixed in the centre of the forehead by way of ornamental decoration. The wasp is known there by the popular name of "Kanch poka, or the Golden Insect."

Ampulex compressa. (Fabr). (Fig. 13).

The habits of this wasp have been described in "Indian Insect Life" at pages 207-208. I have nothing more to add save that these wasps sometimes frequent our houses in search of the big household cockroach.—*Periplaneta americana.* On several occasions I have seen this cockroach being dragged up a wall by this little active wasp, not in the way a paralysed cricket is taken by *Notogonia subtessellata* (Sm.) but like a truant moving schoolwards with unwilling steps when dragged by superior force. The cricket makes no effort to move and is simply dragged like a mere corpse, but the cockroach walks on its own legs. It follows from this that the latter is not so completely paralysed as the former, or in other words, the cockroach is not stung in all the nerve centres; consequently, movement of limbs, though a little restrained, is still allowed it. I should think this action of the wasp deliberate: and it displays very well her intelligence. She realizes fully, it appears, the difficulty she will have to encounter in removing such a heavy load from ground to the top of a house if the cockroach were deprived of its locomotion. Now she simply pulls at an antenna and the big cockroach moves on heavily, although much against its inclination. This concession (partial movements of limbs) so dangerous afterwards to the wasp egg and young larva, is not permitted longer than necessary. The wasp takes care to bite off all such limbs as legs, wings, etc., before laying up the cockroach in the nest as provision for the young.

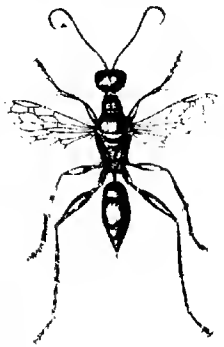

Fig. 13. Ampulex compressa. (I. I. L.)

Economic.—Cockroaches chiefly live on dead and decaying animal and vegetable matter, and as such are good scavengers, but when found in houses in large numbers they are a regular nuisance. *Ampulex compressa* in checking their spread is decidedly beneficial.

Stigmus congruus, Walk.,

and

Stigmus niger, Motsh.

These tiny black wasps have been observed carrying away Aphides, which they probably store in their nest as provisions for the young. An enormous quantity of sap is extracted by Aphides from plants which they infest, and which, consequently, look unhealthy and wither away prematurely. These wasps prove a natural check on them, and are, therefore, beneficial. One of my flowering plants was once badly covered with a yellow species of Aphis, but lady-bird beetles and these wasps appeared in time to clear it of the pest and thus saved it from the inevitable decay.

Bembex orientalis, Handl.

Bembex orientalis, Handl., is the commonest wasp of this genus found at Pusa. It nests in soft sandy soil not far from river banks. The entrance to a nest is more or less a transverse slit. In May 1909 I dug up several nests but from none of these did I obtain any egg, larva or pupa, of the wasp. Perfect wasps, however, were found in them. In the yellow colour of these wasps there was noticed a lovely freshness, which is so peculiar to things which remain screened from the sun. Exposure to the sun's rays changes or bleaches a colour to some extent. For instance, the body of *Myrmecocystus setipes*, Forel, dug out fresh from a nest underground, is yellowish brown, but the colour of specimens caught flying or running outside a nest, is totally brown and tawny: yellowishness completely vanishes away on exposure to sun-light. From this it will easily be inferred that *B. orientalis* must have been present in the imago form in the nest long before my digging them up. It will be within the limits of possibilities then to suppose that hibernation in the case of this wasp takes place in the imago stage.

Philanthus pulcherrimus, Smith.

My note on the habit of this wasp has already appeared in "Indian Insect Life" at page 209 and I reproduce it here.

"This wasp is common at Pusa during the months of March and April. It is usually found on flowering plants, on the flowers of which bees are also hovering. This wasp attacks them, stings them, and then flies away with them to the nest. The bee is held by the wasp below the thorax between the legs. Nests of this wasp are in sandy banks, and are in the form of long narrow tunnels. Females are observed bringing bees, generally belonging to the genera '*Halictus*,' '*Ceratina*' and '*Apis*' to their nests and the choice seems restricted to the family *Apidæ*."

Economic.—The mother-bee generally fills a cell with a mixture of pollen and honey. She is furnished therefore with bristly, branched, plumose, and twisted hairs, which facilitate the work of gathering pollen from flowers. When she buries herself in the blossoms, pollen grains stick to the peculiarly modified hair. As the bee flies from one flower to another of the same plant, some of the pollen grains of the former, come in contact and adhere to the stigma of the latter and pollenize it. Similarly while she flies from one plant to another cross-pollination is accomplished. Thus the bee incidentally pollenizes flowers while collecting pollen which she stores in her cells; and as such she is a very beneficial insect in flower and fruit orchards. *Philanthus pulcherrimus* attacking these is decidedly an injurious wasp.

FAMILY EUMENIDÆ.

Genus EUMENES.

Eumenes affinissima, Sauss Var.

This wasp is shown on Plate XIII, Fig. 11. Single cells of this species have been collected from the branches of Jhau (*Tamarix sp.*). (Pl. XIII, Figs. 9 and 10). The mud used appears to be very finely kneaded, and the cells are very delicate.

Eumenes esuriens, Fabr.

This wasp is similar in habits to *E. conica*. The female wasp constructs mud nests, consisting of three or four cells, and each cell

is stocked with paralysed caterpillars. The nests are found in various odd places, *e.g.*, corners of houses, against walls, rafters and windows and in bamboos, tree-trunks, etc. On one occasion a rejected circular wick of a table lamp was occupied by this wasp. The shape of a cell is very much like that of *Eumenes conica*: being elliptical in plan, and semi-elliptical in section. The wasp takes about 3 hours to raise the cell and about an equal number of hours to store caterpillars in it. A cell which was started at about 11 A.M. one day, was finished by 2 P.M. the same day; and the caterpillars were stored and the cell plugged by 5 P.M. The time required to stock the cell with caterpillars depends on the abundance or scarcity of caterpillars and the distance from which they have to be fetched. If they are found close at hand and in large numbers the time taken will proportionately be very much less than when they have to be brought in from a long way off and are few in number.

The egg, as in the case of *Eumenes conica*, is suspended by means of a fine thread, inside a cell. It hatches in a couple of days, the young larva feeds on the paralysed caterpillars stored in the cell and grows in size. On the 3rd day it measures 12 mm. by 4 mm. and on the 5th day it is full-grown when it commences to line the inside of the cell with silk threads. On the 6th day excreta are discharged and the larva measures 15 mm. by 5 mm. and is yellow in colour. On the 8th day it pupates. In the freshly formed pupa the abdomen is joined on to the thorax broadly, and the segment (petiole) joining these two parts of the body gets thinner and thinner till it is reduced to its ultimate dimensions. The petiole in this stage is never stretched lengthwise but is kept in an oblique position. The abdomen consequently remains more or less at right angles to the longitudinal axis of the pupa. The length of the pupa measured from head to the base of the 2nd abdominal segment is about 11 mm.

The general colour of the pupa is yellowish white and the wing pads are slightly brownish. A change in the colour of eyes takes place on the beginning of the 3rd day after pupation. On the 7th

day reddishness is suffused all over the body: the mesothorax assumes a brick-red colour, the petiole and the abdominal segments becoming reddish brown. All the sutures on the thorax, a transverse band on the petiole and another on the apical margin of the 2nd abdominal segment turn black. On the 9th day yellow markings on the thorax and abdomen appear prominently, and on the 10th day the thin pellicle covering the pupa is cast and the wasp emerges. On the following day the limbs harden and the wasp cuts a hole in one side of the cell and escapes. Thus from egg to imago this wasp takes about 21 days.

Eumenes conica, Fabr.

The female *conica* constructs mud cells in the corners of houses against walls, wooden furniture, etc. There are generally 6 to 10 cells in a complete nest. The cell is convex from outside, elliptical in plan and semi-elliptical in section. The approximate length of a cell measured along the major axis of the plan is 22 mm. and the breadth along the minor axis 12 mm.

The female *conica* brings a mud pellet and lays it out in a curve on the place where she intends to construct her nest. She goes out and brings more mud which is added on to the first curve. Several times the wasp goes out in this way and returns with mud pellets which are worked into the wall of the cell. When the wall rises to a height of about 6 mm. all round, in a plane at right angles to the one against which the nest is being constructed, a gentle curve is given to the remaining portion of the construction which ends in a small central aperture about 4 mm. in diameter surmounted by a structure which may well be compared to the neck of an Indian water pitcher with a rim. Through the aperture are slid in well developed green caterpillars (generally semi-loopers), which are brought stung and paralysed (but *never dead*), to be laid up as provision for her young. (Note :—The caterpillars are sometimes found to be parasitised.)

The number of these caterpillars in a cell varies; usually it is five, but if the caterpillars are small and not fully developed, their

number may be nine or more; and in case the wasp is scared away, caught or killed before closing the cell, the number of caterpillars stored is much less.

When the egg is laid and the necessary number of caterpillars has been stored in a cell, the pitcher-rim structure is demolished a little and the central aperture is plugged with mud. Another cell is started just above it, the lower side of the second touching the upper side of the first; but in case the nest is located in a corner, the cells overlap each other to some extent. Thus cells are added on one after another, till the required number is reached.

As already remarked *E. conica* may construct 7 to 10 cells in one place if not disturbed, but if, on each return to an unfinished cell, she finds someone closely watching her nest, she quits it, suspecting some mischief and starts a new nest in some other locality. It is partly due to this reason that one generally comes across such nests as have two or three cells closed and the top-most cell with the characteristic pitcher-neck still existing. Sometimes solitary unclosed cells are also found for similar reasons. As a rule, one egg is laid in a cell; only in one case I found three very similar eggs suspended in an unclosed cell. In her egg-laying habit *Eumenes conica* differs from some wasps, as the egg is not laid on the food of the larva, but is suspended by means of a very fine thread from what we may call the roof of the cell. The length of a freshly laid egg is about 3·2 mm. and that of the thread about 1·5 mm. The colour is uniformly yellowish white, but later on only the portion occupied by the embryo retains this colour and the rest of it (near both the ends) becomes colourless. It gradually increases in length to about 4·5 mm. and in shape is long and cylindrical (slightly curved) with ends rounded. The egg stage lasts for about 2 days. The egg splits on one side, and the rent gradually increases downwards till the larva puts forth its head and as much of its body as may enable it to reach the food below. It does not leave the egg-shell so long it can get at the food from its suspended position, and so long as it is too delicate to receive convulsive strokes from the paralysed caterpillars. When freshly hatched the larva measures about 4 or 4·5 mm. long and

1 mm. broad. It is green in the middle, the anterior and posterior ends being colourless. This green colour deepens and then gradually spreads all over till some yellow appears mingled with it, the latter colour predominating eventually. It moults three times prior to its attaining full length.

The following table gives the dates of different moults as observed in the case of two larvæ:

Hatched	...	.. 20th March (night)	22nd March (night).
1st moult	...	.. 21st ,,	23rd ,,
2nd ,,	..	.. 22nd ,,	24th ,,
3rd ,,	..	.. 23rd ,,	25th ,,
Pupated	..	. 3rd April (at 3 P.M.)	5th April (night).

When, in a week's time, it is full grown, it has the appearance of a yellow mass of flesh tapering towards both ends, and divided into distinctly marked segments. It is about 19 to 20 mm. long and 6 to 9 mm. broad in its widest portion. It has ten small round spiracles on each side of the body.

In the cell the full-grown larva spins a cocoon, inside which it rests for some days before pupating; but if taken out of the cell it hardly spins any cocoon, and, if at all, only a few threads are drawn across the body. The cocoon is of a very thin consistency and is spun quite close to the walls of the cell: practically the cell is lined with silk threads. It serves two purposes (*i*) keeping the pupa enclosed in a soft covering and (*ii*) hardening up the wall. It has been observed that a cell containing a pupa offers greater resistance to breaking than one containing a larva. It may also be noted in this connection that almost all the mud-nest-making wasps appear to add something of the nature of saliva to mud to make it more sticky and hard: for it is comparatively much easier to break a cell made by human hands than one constructed by a wasp, even though the mud used in both the cases be the same.

Excreta are discharged inside the cocoon, and the larva becomes motionless. The colour turns to a delightful yellow and the body is much contracted. After 3 to 5 days' rest, the fifth and sixth segments of the body (reckoned from head end) are narrowed. This announces that the insect is about to enter upon the third

stage (pupal) of its metamorphosis. The larval skin is shed and there appears a wonderful change in the insect. It is no longer a tapering mass of flesh, but has all the limbs of the perfect wasp. Head, eyes, antennæ and its joints, thorax, legs and its joints, and abdomen, in fact, every part of the body comes out distinct and clear except the petiole which is very broad and thick. The abdomen appears to be broadly joined on to the thorax, as in the case of Sessiliventres. The petiole gradually reduces to its normal dimensions by the following day. The colour of the pupa at this stage is light yellow all over, excepting the antennal and tarsal joints which are white or colourless and the rudimentary wings which are brownish. The pupa when fresh measures 12—13·5mm., and increases in size as the petiole gets thinner and longer. Then follows a gradual change in colouration. The eyes exhibit signs of change first; two days after pupation they get a slightly pinkish tinge which deepens on the 3rd day; on the 4th day the eyes get slate-coloured; on the 5th day there is more of darkness and only an obsolescent tinge of bluishness. On the 6th day, eyes are black, though not quite. There is just a reddish tinge all over the body; and there also appear a thick black line behind the eyes, a longitudinal black line traversing half the length of the mesonotum, another transverse stripe on the middle of the 2nd abdominal segment above. The different parts of the thorax come out clear and distinct. On the 7th day after pupation the different segments of the abdomen become separated and lateral pinkish lines appear on them. Excepting antennæ, legs and the ventral side of the abdomen, the whole insect becomes reddish, the sutures between the pro- and meso-thorax, meso-thorax and scutellum become dark. The insect becomes more red day after day till the dull red colour of the perfect wasp appears on the 10th day after pupation. The clypeus, sinus in the eyes and narrow stripes behind them become yellow. Up to this day the wings do not appear developed, and in their place one finds thick pads of skin, covering the meso- and meta-pleuræ. On or about the 12th day the thin pellicle covering the pupa is cast off, and at once the long, longitudinally-folded wings appear. For this day the

wings are kept over the body parallel to it, but on the next day when the wasp gets dry they are spread out almost at right angles to the body. This happens when a larva is taken out of a cell and bred in a cage, but if allowed to complete its metamorphosis inside a cell, the perfect wasp remains inactive for a day and on the following day, when the limbs are hardened, emerges from the cell through a hole cut in the upper side.

Thus the period occupied from egg to imago is four weeks :

Egg stage about	... 2 days.
Larval stage (including resting stage) ..	... 9 to 14 days.
Pupal stage about	... 12 to 13 days.
TOTAL	... 23 to 29 days.

As mentioned above, sometimes the uppermost cell in a nest is found unclosed with only a couple of caterpillars in it for the larva. The larva on finishing this short supply of caterpillars undergoes metamorphosis just as a full-fed larva would do. Casting off the larval skin and pupal pellicle, gradual changes of colouration in the pupal stage, and the final emergence as a perfect wasp, take place all at regular intervals.* There is, however, a great difference in the size of the perfect wasps which emerge : the one from a full-fed larva is very much bigger and consequently stronger than the one whose supply was stinted. This points to an important conclusion that difference in the size of various specimens of *E. conica* of the same sex, depends largely on the quantity of nourishment received during their larval stage.

Enemies.—Stilbum cyanurum, Först., *Chrysis fuscipennis*, Br., and *Chrysis orientalis*, Guér., of the family Chrysidæ, two undetermined

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* *From my note-book*—(June 1908).

"Two larvæ of *E. conica*, taken out one from a closed cell, the other from an opened one ; the former is full-fed and well developed, in resting stage ; the latter much smaller in size, resting.

No. 1. Pupated on 23rd June 1908 (night).
Emerged 5th July 1908.
No. 2. Pupated on 25th June 1908 (noon).
Emerged 6th July 1908.

Both are females, No. 1 very much bigger than No. 2."

species of the family Tachinidæ and *Mutilla regia*, Sm., have been bred here from the cells of this wasp. Chrysids pupate inside a tough reddish-brown (sometimes yellowish-brown) cocoon which the full-grown larva spins in a corner of a cell (Plate II, Fig. 12*a*). Tachinid puparia are found loose inside a cell. Sometimes it so happens that both the parasites, Chrysids and Tachinids are found in the same nest; the emergence of Tachinids from a nest is always perplexing, for it cannot be definitely decided whether the flies bred are parasitic on the caterpillars stored in cells, or on the wasp larva or pupa. I am inclined to believe that the maggots which eat up the caterpillars would not spare the wasp larva; however, flies whose maggots have been found to feed purely on wasp larvæ or pupæ, have been ascertained to be quite distinct from those parasitic on the caterpillars. Below I quote a few observations from my note-book which will throw some light on the subject and elucidate some other points too.

8th April 1909.—"Removed a mud nest of *Eumenes conica*, consisting of six cells, from a window in a house (Pl. XIII, Fig. 12). Out of six, two of the cells contained nothing; of the remaining four in two cells were seen Chrysid larvæ, in the 3rd a Tachinid puparium and in the 4th a full-sized pupa of *E. conica*.

"Just above the pupa, and separated from it by the full-grown larva's thin cocoon, was found a Tachinid puparium (a damaged one containing a dried-up fly), and on the pupa itself near its prothorax a tiny Chrysid larva: (Plate XIII, Fig. 13).* Now it was a puzzle; how could the wasp larva advance to the pupal stage when the Tachinid parasite was also in the cell? On what was the Tachinid maggot nourished? Not on the wasp larva, because it was there in the pupal stage. It must have been, therefore, consuming the food-supply of the wasp larva. The mother *conica* might have stored in the cell, as she occasionally does, a parasitised caterpillar, which by mere chance might have got only one parasitic maggot on it. The

* The tiny larva mentioned above as having been found on the prothorax of *E. conica* pupa, pupated on 18th April 1909 inside a tough cocoon in the cell: the *Chrysid* wasp (*Chrysis fuscipennis*) emerged on 2nd May 1909 (Pl. XIII, Fig. 11).

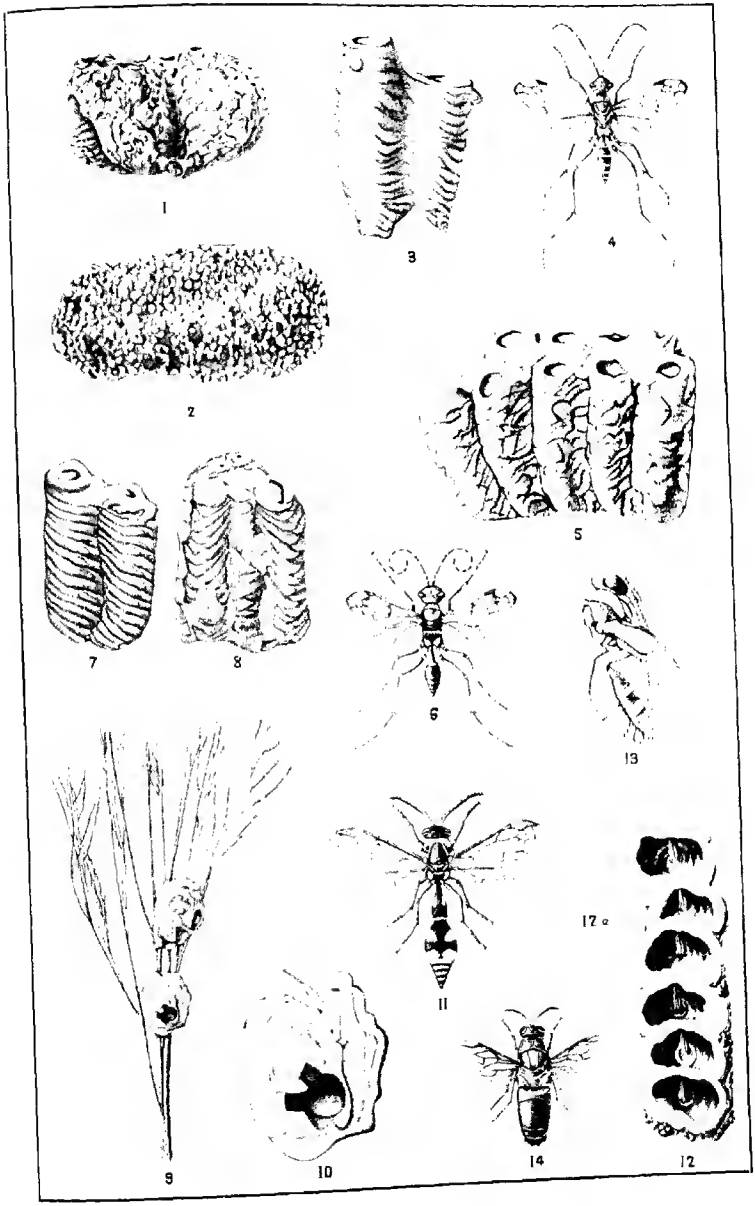
EXPLANATION OF PLATE XIII.

1. Nest of Sceliphron coromandelicum, reduced × $\frac{2}{3}$.
2. „ „ inhabited by Pseudagenia clypeata × $\frac{2}{3}$.
3. „ „ Pseudagenia blanda × 2.
4. Pseudagenia blanda, male × 2.
5. Nest of a Pseudagenia sp. × 3.
6. Pseudagenia sp., female × 3.
7. Cells from an unfinished nest of Sceliphron coromandelicum. } Natural size.
8. Cells from an unfinished nest of Sceliphron madraspatanum. } Natural size.
9. Cells of Eumenes affinissima, var. on a branch of Tamarix. } Natural size.
10. A single cell of the above × 3.
11. Eumenes affinissima var., female × 2.
12. Nest of Eumenes conica as seen from underside × $\frac{2}{3}$.

12a. Cocoon of Chrysis fuscipennis in a corner of a cell.

13. Eumenes conica pupa bearing Chrysis fuscipennis larva on the prothorax × 2.
14. Chrysis fuscipennis × 2.

PLATE XIII.



maggot pupated after consuming the caterpillar and allowed the wasp larva to flourish unmolested. This is on the assumption that the Tachinid maggot requires only one caterpillar for its full growth."

To ascertain definitely how many caterpillars are consumed by a Tachinid maggot before it is full-fed, I broke open several freshly constructed *E. conica* cells: and from one I got a parasitised caterpillar. On this caterpillar were seen five tiny maggots. In the cell there were two more caterpillars besides the parasitised one and the cell was not yet closed. The maggots grew in size gradually: the three caterpillars were consumed clean: their integument alone was left. I put in one more caterpillar which was not paralysed: but only a little crushed, and of nearly the same size as those found in the cell: it was finished; two more were added next, of which one remained uneaten. At this stage the maggots began to pupate. Thus five caterpillars in all were consumed by five maggots, showing that one caterpillar is quite sufficient for one maggot.

It may be noted here that the full-grown maggots measure 7 to 8 mm. in length, and 3 mm. in breadth (in the middle): colour is dirty white: general shape, tapering towards the head end and abruptly truncate towards the tail end. The maggots before pupating contract their body very much, and the puparium is 4·5 mm. long and 2 mm. broad. The colour of a puparium is bright testaceous which gradually turns to dark-brown. The pupal stage lasts for about 12 days. (Note.—The flies that emerged from these puparia have been ascertained to be quite distinct from those reared actually on wasp pupæ).

13th July 1909.—"On removing a nest of *Eumenes conica*, I found in one cell Tachinid maggots actually eating into the wasp pupa. The maggots pupated on 15th July 1909 and the flies emerged on the 25th idem." Again, early in October 1909, I removed another nest of this wasp from which I got a pupa damaged in a similar way. Flies which emerged in both these cases were different from those bred on caterpillars. Emergence of the Tachinid flies takes place probably in the same way as described

under *Sceliphron coromandelicum*, for the maggots have been found in this case also to bore their way into adjoining cells in search of food.*

Economic.—As already remarked, *E. conica* stores in her cells paralysed caterpillars which are chiefly semi-loopers. Since it is difficult to identify insects in the caterpillar stage I have not been able to definitely determine the paralysed species. To rear them to moths is rather difficult on account of the poison which the wasp injects into their body. The only way to accurately decide this question is to find out the food-plant of these caterpillars, *i.e.*, to ascertain and see the actual plants from which the caterpillars are carried away by the wasp, and in this direction I have not been successful yet. In one case the caterpillars resembled those of *Cosmophila sabulifera*, Guén., and in another they looked very much like the caterpillars of *Trigonodes hyppasia*, Cram.

Caterpillars are generally herbivorous, and when they increase abnormally on a particular crop, they may do great damage. *Eumenes conica*, exercising some check on these (however little) is decidedly then a beneficial wasp. Cells of this wasp are freely parasitised. Sometimes from a nest of seven or ten cells not a single wasp emerges. Taking five as the average number of cells in a nest and two as the average number of wasps that emerge from each nest (one being male and the other female), we find that 25 caterpillars will be paralysed in the 1st brood :† an equal number of them in the 2nd brood, and so on. In case there are six broods a year, the total number of caterpillars paralysed by a single wasp (which started nest-making from the middle of April) and its progeny will be $6 \times 25 = 150$. And as these wasps are never numerous at any time of the year what an insignificant fraction

* But in one instance I found the Tachinid flies emerging by pushing aside a little clay from the nest. This particle of clay did not fall off the nest but was held in position by some threads (probably those with which the full-grown wasp larva had lined the inside of the cell). It opened like a door on hinges. The exit hole was not cut and the clay was removed from that portion of the cell where no extra mud was put by the mother wasp and where evidently the head end of the maggots had worked like a drill. This nest was under my observation during August 1902, when this memoir was in the press.

† Providing the female dies or cannot lay more eggs after completing the first nest.

of the huge number of caterpillars that yearly devastate our crops, is incapacitated by these wasps. Still I would not condemn the good done by them, even though it is so little.

Now consider the other side of the question. Is the wasp capable of doing any harm? If so, to what actual extent? She can sting and perhaps severely, but I have not heard or seen anybody stung by this wasp, nor have I myself had this experience, although I have been so closely and familiarly intimate with her for over three years. *E. conica* no doubt disfigures our furniture, boxes, windows, and neatly white-washed walls by her ugly mud nests, and this is the only fault we can find with her.

General.—The paralysed caterpillars stored by this wasp in her cells have been observed sometimes to pupate successfully, but it is seldom that the pupæ turn to imagines. In one case, however, I remember that a mulberry silkworm, which was removed by the wasp from the silk house, on being rescued from the cell, spun a flimsy cocoon, and the moth emerged in due course.*

Caterpillars belonging to the following families have been obtained from the cells of this wasp.

1. Caterpillars resembling those of *Anaphis* (*Belenois*) *mesentina*, Cram. Family 'Pieridæ.'
2. ,, ,, (i) *Chloridea obsoleta*. (ii) *Cosmophila sabulifera*, Guén. (iii) *Trigonodes hyppasia*, Cram. Family Noctuidæ
3. ,, ,, (i) *Deloneia capitata*, Wlk. (ii) *Tephrina disputaria*, Guén. Family 'Geometridæ'
4. ,, ,, *Bombyx mori*, Linn. Family 'Bombycidæ'

In the empty cells of this species *Megachile lanata* has been observed to nest.

Eumenes edwardsii, Sauss.

In October 1908 I got a cylindrical clay cell, with rounded ends, attached singly to a blade of grass. Measurements of the cell were—Height 14 mm.; Diameter of the cylinder about 10 mm. *Eumenes edwardsii*, Sauss., emerged making a hole at the top.

* On 21st March 1912 I removed a few Noctuid caterpillars from a cell. Almost all the caterpillars pupated, but only one turned to moth which proved on examination to be an example of *Pterophora reflexa*, Guén.

Genus Rhynchium.

Four species of this genus are found at Pusa. *R. brunneum*, F., *R. nitidulum*, F., *R. metallicum*, Sauss., and *R. bengalense*, Sauss. All these wasps stock their nests with paralysed caterpillars and as such are 'Beneficial Insects.' The last named species is found to be infested with *Strepsiptera*.

Rhynchium brunneum, Fabr.

This wasp also, like many others, takes advantage of ready-made holes in which she stores caterpillars as provision for her larvæ. In each cell there may be a dozen of these caterpillars. This wasp is found at Pusa from April to October, but becomes abundant during August and September.

Once (14th August 1908) I observed this wasp entering a hollow in a dried piece of bamboo. She remained inside it for a few minutes and flew out again. She returned after 10 minutes with a caterpillar. She entered the hollow and I thrust in a bent wire behind her. The wasp rushed out buzzing angrily round my head and finally went away. During her absence I managed to remove a couple of caterpillars out of her nest. She returned again, but this time without a caterpillar. (She went out it appears to select a suitable site to shift her nest to). She sat just outside the nest, and then very cautiously entered it. She came out with two or three caterpillars which she carried to another bamboo with a similar hollow in it. Thus all the caterpillars were removed to a new place on such a slight provocation. The caterpillars were of the description given below:—

General shape—Slender, long (17 mm.) cylindrical with the usual five pairs of suckerfeet. Half the body towards the head end in almost all the specimens is yellow with an obsolescent tinge of green above, and the remaining half green. Head light brown with a few pale hairs chiefly on the sides. Prothorax yellowish-brown with black marks posteriorly arranged in a semi-circle. The following two segments have two central oval black marks, each with two black dots inside from which springs a single hair. There are

two more oval marks just behind these, but without central dots, and, lastly, two oval marks on each side with one central black dot bearing a hair. The remaining segments are uniformly marked. Each of them has five marks arranged in two lines, three in one and two in the other.

1st line.—Three marks, two black circular rings, one on each side of a central black oval mark, which is bisected by a faint dark longitudinal line. Each half has a black dot in it bearing a single hair. Similarly the side rings have one dot each, with one hair. The central mark is longer than the side ones.

2nd line.—Two black oval marks and a black spot in each bearing a single hair.

On each side of the body there are 9 black round spiracles. Identified as caterpillars of *Marasmia trapezalis*, Guer.

Economic.—This wasp is decidedly a beneficial insect. It exercises some influence in keeping down the caterpillars of the above-named Pyralid, which is one of the pests of Maize.

Rhynchium nitidulum, Fabr.

This wasp constructs long oval clay cells which are coated with a black gummy substance obtained from certain trees, such as Pipal (*Ficus religiosa*), Babul (*Acacia arabica*), etc. A single nest may contain in some cases up to 25 cells (Fig. 14), but 5 to 10 is the usual number. The nest may be stuck against the ceiling of a house, or it may be inside a hollow of a tree. It is

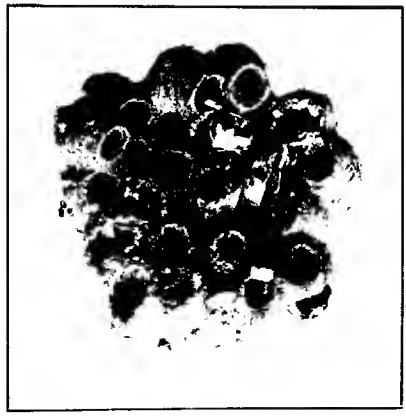


Fig. 14. Nest of Rhynchium nitidulum. (From a photograph.)

never attached by a narrow stalk (as in the case of *Polistes hebræus*, etc.), but the bottom of a couple of cells is firmly adherent to the surface against which a nest is constructed.

The wasp takes nearly half a day to construct a cell and the remaining half of the day is spent in coating it from outside with gum. Paralysed caterpillars are then stored up, and this work may occupy the wasp for 3 to 6 hours. The cell is then closed, and after 30 to 33 days the wasp emerges from it. From 3 cells which were kept under observation, the wasps emerged on the following dates:

No.	Cell closed on		Wasp emerged on
1.	25th September 1910	...	.. 25th October 1910.
2.	29th ,, ,,	...	.. 30th ,, ,,
3.	3rd October ,,	...	.. 5th November ,,

Chalcid parasites have been reared from the cells of this wasp.

Rhynchium metallicum, Sauss.

This wasp has been observed carrying away Tineid (*Senon latiore*) caterpillars from a plant locally known as "Chakaur" (*Cassia tora*). The caterpillars have the habit of folding up four or five top-shoot leaves together. The wasp knows such leaves to contain her prey: she comes to the plant directly and settles down on the folded top-shoots. An opening is cut from below, the mandibles are thrust in, and the caterpillar is ousted from its hiding place. At once the wasp pounces on it, stings and flies away with it.

FAMILY APIDÆ.

Ceratina viridissima, Dall. Torr.

This is a beautiful bee of a charming green colour, with metallic blue or golden shades. It is sometimes confused with *Chrysid* wasps from which it can be readily distinguished by the forewing venation. The *Ceratina* has three cubital cells, while the *Chrysid* has none (rarely one).

It nests in hollow reeds and thatch, and excavates tunnels in dried pithy branches of trees. These tunnels and hollows are made

by the female bee in an exquisite way : the inside of the nest is turned perfectly smooth. A file and sand paper would not finish it smoother. The fine particles of saw-dust are not scattered to the winds, but are compressed and utilised as partitioning walls between the different cells of a nest. In a nest there may be about 5 cells and each cell is about 8 mm. in length : in shape it is a perfect cylinder. Each cell is provisioned with a little bee-bread which is pollen mixed with honey. On this an egg is laid.

I have ascertained that an egg after it has been laid by the bee increases in length from about 2 mm. to about 3 mm. It is long, a little curved, semi-transparent and very smooth. The thin pellicle constituting the egg shell bursts at one end and the larva pushes its head out. Shortly afterwards the smooth body gets a little wrinkled. As the thin pellicle simply rolls over the larva remains in exactly the same position as the egg, only the wrinkled body tells us that the insect has advanced to the second stage of its development.

The larva on hatching begins to feed on the bee-bread. When freshly hatched it measures a little more than 3 mm. Head is distinct and shiny white. Body is longitudinally margined and transversely ridged. Six spiracles are visible on each side. Larva when half developed is dirty white and yellowish in colour : in the middle above slightly brownish, towards the tail-end black. Medially a faint dark line, extending from head to the apex of abdomen is visible below the integument.

Development of the larva is slow and when it is full-grown it is about 8 mm. long. Head and thorax creamy white, semi-transparent, the rest of the body yellow (colour of bee-bread) ; the posterior segments are distinct. Just a line to mark the outer margins of mandibles reddish. Head inclined downwards. The larva placed on a horizontal surface always remains in a curved position. Larval and resting stages occupy 10 to 13 days.

Description of one or two days' old pupa is given below :—

Length 6 mm. General colour is yellowish ; apical joints of flagellum, all tibiæ, tarsi, and mouth-parts, whitish.

Head.—Labrum, mandibles, clypeus, eyes, antennæ and its joints distinct. Ligula and palpi exserted, and placed below the thorax parallel to the longitudinal axis of the pupa, between the tarsi of the legs which are folded symmetrically on the ventral surface. Eyes and ocelli can also be traced feebly.

Thorax.—From above smooth and shining, all sutures well marked; two longitudinal depressions on the meso-thorax; median segment posteriorly vertically truncate. Wings in rudimentary stage, lying obliquely on meso- and meta-pleura.

Abdomen.—Six or seven segments distinct, a little longer than broad, much narrowed towards the apex.

FIG. 15. CERATINA VIRIDISSIMA PUPA IN CELL, AND EMPTY CELL (L. L.).

The pupa, when placed on a horizontal surface, moves the abdomen right and left. By this motion it cannot go forward or backward, but can move more or less in a curve. Another noteworthy point in this connection is that the full-grown larva does not spin any cocoon, consequently the pupa is always found naked in a cell (Fig. 15). Changes in the colouration of the pupa take place in the same way as in other Aculeates. First, the eyes become pink and ocelli chestnut brown; gradually they turn black. The thorax and abdomen by degrees become green, and then the thin pellicle covering the pupa is shed and the perfect bee appears in its charming colour. Pupal stage lasts from 11 to 18 days.

Thus from egg to imago the bee takes from four to five weeks.

Egg stage	3	to	4	days.
Larval stage including "Resting stage" ...	10	„	13	„
Pupal stage	11	„	18	„
TOTAL ...	24	„	35	days.

As already noticed, the female bee nests in reed, thatch, hollowed-out dry branches of trees and dry shoots of bamboo. The first cell

is started right inside the hollow and the last cell is finished near the entrance (open end); consequently if in the cell constructed last there is an egg, the cell constructed 1st (*i.e.*, the last cell counted from the open end) would contain a full-grown or a nearly full-grown larva. Naturally enough the inmate of the first cell becomes an imago, while the occupants of other cells are still in pupal and larval stage. How does the bee of this cell manage to come out of the nest when the exit is blocked? After repeated observations I have come to the conclusion that the bees remain in their respective cells after shedding pupal skins and wait patiently there till the inmates of the succeeding cells leave a clear passage for them to emerge from the nest.

The bee pupa lies in a cell with head towards the closed end of the nest. On reaching the imago stage it stands on its legs and instinctively tries to walk forward and backwards. It pushes the sawdust plugs, and if the adjoining cells are occupied, the plugs will remain intact: but if, on the other hand, the next cell (towards the open end) is vacant, the bee in her backward motion will demolish the sawdust wall and escape from the nest.

At night these bees hide themselves in such hollows as they choose for their nests, the mother bee always confining herself to her own nest. Early in the morning, five or six of these bees may be found huddled together in the central hollow of a single dried shoot of a bamboo.

Enemies.—Tiny black '*Chalcid*' parasites have been bred from the cells of this bee. In one cell there may be found as many as four dirty white larvae feeding on the bee-larva. These larvae, when full fed, do not spin any cocoon, but simply cast off their skins and pupate. The pupa is naked, white, about 3 mm. to 4 mm. in length, with all the limbs of the imago. About two days after pupation the eyes turn pinkish and gradually become deeper in colour. On the following day the whole of the body turns black and a couple of days after the parasite emerges.

Economic.—We have seen that *C. viridissima* stores pollen and honey in her cells. In order to facilitate the work of gathering

pollen, nature has furnished her with peculiarly modified hairs. On her tibiæ the hairs are branched and forked (as shown in figure 16; Fig. 16*a* shows a single hair magnified). Thus when she buries herself and rolls in the blossom, pollen grains adhere to these hairs. As she flies from one flower to another of the same plant, pollen grains of the one come in contact and stick to the stigma of the other and pollenize it. Similarly when she flies from one plant to another cross-pollination is accomplished. It will be clear from this that from an economic point of view this bee is very valuable in fruit and flower gardens.

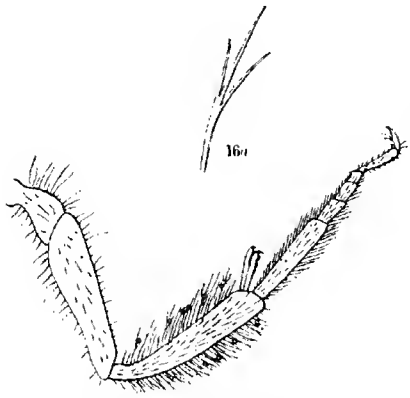


FIG. 16.—BRANCHED HAIRS ON THE TIBIA OF CERATINA VIRIDISSIMA.

FIG. 16*a*.—A SINGLE HAIR MAGNIFIED.

FAMILY FORMICIDÆ.

Dorylus labiatus, Shuck.

In the month of February each year males of this species, which are very wasp-like in appearance (Fig. 17), generally come at night into houses attracted by light. Workers have been found twice a year in large numbers: once in February and again in August. In size they are very much smaller than the males, in habits they are usually carnivorous. One afternoon (20th August, 1908) after a brisk

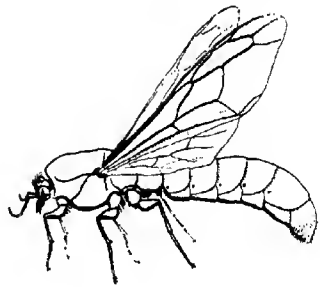


FIG. 17.—DORYLUS LABIATUS MALE—1½ (I. I. L.)

shower of rain workers of this species came out in large numbers from their nest which was underground, near the foot of a wall. On this wall at that time were also moving upwards workers of *Phidole indica* with males, eggs, larvæ and pupæ. The *labiatus* workers attacked them and, grasping them between the mandibles, ran into the nest. On digging up the nest a little, I found several *Phidole indica*, Mayr., workers cut into pieces or badly mutilated.

Workers of this species are blind, but it was interesting to behold them pouncing on the *Phidole* workers with great precision. They live underground chiefly on animal food, and hunt small ants and little living things which multiply so enormously as to become a nuisance at times. *D. labiatus* in this respect is a beneficial ant to some extent.

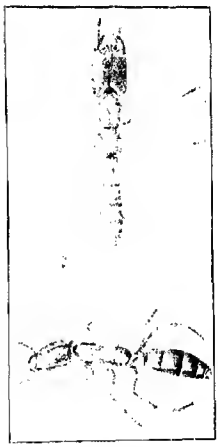


Fig. 18. Dorylus orientalis Workers. (I. I. L.)

Dorylus orientalis, Westw., is a species very closely allied to the above. Males of this species can be distinguished from those of *labiatus* by their smaller size and broader mandibles, and workers by the number of antennal joints which are nine in the case of the former and ten in that of the latter.

Workers of this species (Fig. 18) are injurious insects, because they have been observed to actually eat up healthy plant tissue. At Pusa they have been found to damage vegetable crops, but never seriously.

Platythyrea victoriæ. Forel.

This ant is found walking on the trunk of trees examining depressions and spaces covered by loosened bark. I have seen this ant attacking a small tree spider which was hidden under a portion of the bark on an old *Ficus* tree. As soon as the ant approached the spider, the latter jumped out and hid itself in another place. The ant followed it there and the spider returned to its first hiding place. Thus five times was the spider ousted from its retreat and attacked but it always managed to escape unhurt by its agile movements.

Diacamma vagans, Smith.

This ant is seen at Pusa throughout the year and is one of the commonest insects found here. Nests are underground, at the base of big old trees, and near the roots of bamboo clumps. Pupæ of this species are encased in dark-brown cocoons. Outside the nests are noticed generally severed heads of *Camponotus compressus*, F.

Sima rufonigra, Jerd.

Nests of this species are generally found high up in the main trunk or branches of trees, and sometimes in bamboos also. I found one nest in a dried deformed bamboo standing in the midst of a thick clump. Neat and somewhat circular holes were visible on the outside (Fig. 19). These were the entrances to the nest. Fig. 20 represents the cross-section of the bamboo piece; 'a' is the central hollow, b & c mark the position of passages inside the nest.

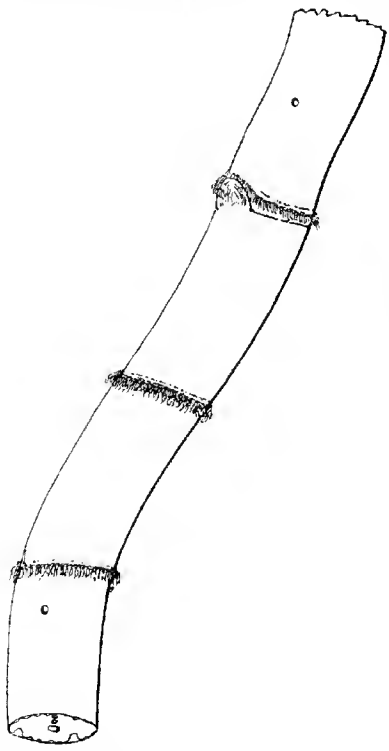


FIG. 19.—NEST OF SIMA RUFONIGRA IN A DRIED DEFORMED BAMBOO.

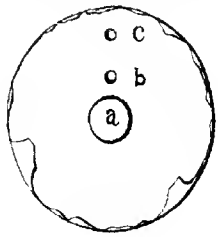
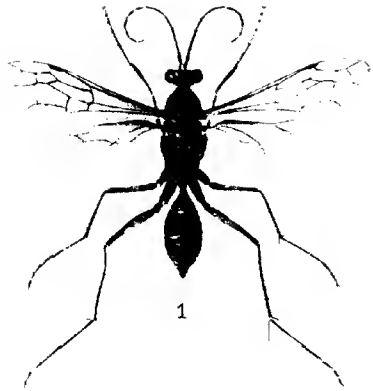


FIG. 20.—CROSS SECTION OF THE ABOVE SHOWING THE POSITION OF PASSAGES LEADING INSIDE THE NEST.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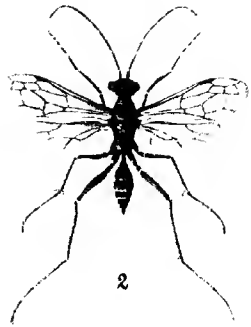
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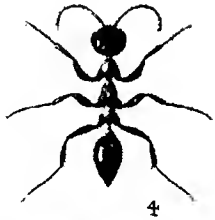
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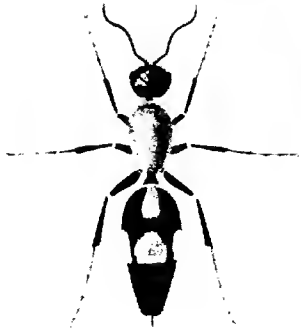
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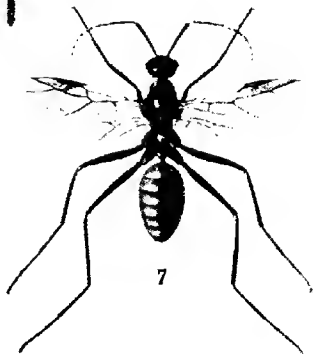
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EXPLANATION OF PLATE XIV.

1. Pseudagenia blanda ♀ } Magnified about 3 times.
2. „ „ ♂ }
3. Spider which mimicks Sima rufonigra ☿ × 3.
4. Methoca rufonigra ♀ × 3.
5. Sima rufonigra ☿ × 3.
6. Mutilla sp. ♀ × 8.
7. Myrmecocystus setipes ♂ × 3.
7a. Last segment of the above showing exserted genetalia. ×

Larvæ are white, cylindrical, with ends rounded, 5 mm. in length. There is a fine medial longitudinal black line above extending over a few segments of the body in the middle. The integument is transparent and through it is visible a black ring encircling the central portion of the body. The head is bent downwards and rests on the ventral side, forming an emargination in the convexity of the undersurface. Once I observed workers of this species attacking those of the ' Harvesting Ant '—*Holcomyrmex scabriceps*, Mayr., which were returning to their nest laden with grains of oats from a neighbouring field. *Rufonigra* did not carry *'scabriceps'* living or dead to the nest, nor did they plunder the latter, but simply took pleasure in killing them or leaving them half dead on the field. The workers of this species are mimicked by a spider which is shown on Pl. III, fig. 3 ; fig. 5 is the worker.

Sima allaborans, Walk.

Nests of this species have been found in the tender shoots bamboos, and also in the main trunk and branches of trees. In the former case the central hollow is utilised for the nest.

These ants when disturbed discharge a drop of white fluid through the anal tube.

Cataulacus taprobanæ, Sm. and *C. latus* Forel.

Cataulacus taprobanæ, Smith, has been found nesting in the hollow of bamboo shoots and *Cataulacus latus*, Forel, in the branches of ' teak ' and ' sarish ' trees. Ants of both the species are jet black and very inactive ; the former is smaller in size than the latter and has orange-red tibiæ.

Cremastogaster subnuda, Mayr.

This species is strictly a tree-ant. The nest may be either in the main trunk or in one of the branches of the tree on which these ants are found running. On a Ber tree a nest was found in the hollow made by the ' Ber shoot borer ' (*Arbela tetraonis*, Mo). On the branches of a young Ber tree I noticed a couple of Mantis egg-cases which were infested with these ants ; some were going inside

them and others were walking on the outside. On opening the egg-cases it was found that the portions visited by the ants were simply dry and empty, but the innermost portion was quite intact.

These ants were observed attending Mealy bugs, *Cerococcus sp.*, on tender Ber shoots, and also the Lac insect (*Tachardia lacca*). These ants in their eagerness to obtain honey-dew from the latter often nip off the ends of the white filaments, the two anterior of which are connected with the respiratory apparatus of the Lac insect, and thus kill it.

Pupæ of this species are naked and the sexes winged.

Monomorium indicum. Forel.

During wet weather individuals of this species enormously increase in number and often become a nuisance in houses. Their nests exist generally underground and sometimes not a single hole in the pucca masonry is left unoccupied. In the monsoon season of 1909 a very large colony of this species established itself in the College building at Pusa, and there were no less than a score of well populated nests scattered all over the building. Individuals of these nests became extremely abundant and nothing was safe from their attack. They got into cages in which insects were reared: they spoiled fresh specimens of insects on setting boards, and old specimens in the boxes when they were left opened on the working table for a while; in short, they grew very troublesome and I undertook to drive them out of the building. I began with pouring simple kerosene oil into all the nests. This measure succeeded in killing a few workers and making the rest quit the nests, only to occupy the first available hole in the vicinity. Kerosene-treatment was extended to these newly occupied holes which were quitted likewise. Thus after the fourth treatment no nest was left in the floor, but the ants were not entirely got rid of. They took to occupying holes in the walls. Kerosene oil in these cases could not penetrate so easily and so far inside the nests as when these were situated in the floor. Consequently the ants did not vacate the nests this time, but emerged through another hole below or above the one

through which kerosene oil was injected and after a couple of days began to use the original entrance to the nest again.

Next I plugged up all holes with white putty after pouring in kerosene oil. This stopped the emergence of the ants, but only temporarily. After a few days I found the plugs bored through and streams of workers flowing out. I then tried white putty well rubbed with kerosene oil to stop the holes, but with little success. My next effort was to stop the holes after injecting kerosene, with white putty thoroughly rubbed into a paste with pure Benzene. This measure succeeded very well, and although it is now more than two years ago that the plugs were put on they are still intact. I am not inclined to believe that the ants were stifled and thus died inside, but in all probability they escaped, how and from where I am unable to tell. I only know this much, that they were never seen afterwards in the College building.

From all that I have seen I am of opinion that the success of a particular measure, undertaken to drive this species out of a building, depends more on the persistence and perseverance with which a measure is carried out than on the property of the substance used. What I have found necessary in the case of this ant is to make the whole colony feel that there is a superior force which is bent upon extirpating them: and this can easily be done by daily killing a large number of these ants continuously for some days.

By daily pouring kerosene in nests which were in the floor of the College building I killed several workers, but could never finish them wholesale. The ants felt much disconcerted there, and resorted to the holes in the walls which they thought to be more secure, but when they were persecuted still more vigorously in their new abode, they realized they were not safe and were consequently under the painful necessity of abandoning the building.

One morning (3rd July 1909) I observed the inmates of a nest marching out with young ones. Close to the nest was sitting a Muscid fly (*Ochromyia* sp.) which attacked from time to time the larvæ and pupæ that were being carried by the workers. The fly never snatched the victim from the grasp of the ant, but simply

'licked' it from its place with the proboscis, which when withdrawn left the larva or pupa quite shrivelled up.

Monomorium destructor, Jerd.

These are very pretty-looking small red ants, with a dark-brown abdomen, which has a sordid yellow colour at the base. They are found in houses usually on substances which have a little grease sticking on them, *e.g.*, combs, hair brushes, corks of phials containing hair oils, etc. On one occasion, however, I noticed a long stream of workers of this species emerging from my store room, each worker carrying a particle of some white substance between the mandibles. I traced them back to a vessel containing wheat flour in which hundreds of these ants were gathered. On another occasion, I traced them to a hole in a Sann-hemp stick in the wall of a thatched hut. The central portion of a Sann-hemp stick is pithy; this soft substance was removed by these ants and a long cavity formed in the stick extending from base to top to serve as a nest. From this nest I obtained winged males (20th July 1908).

The ants of this species bite severely and their bite is very painful. This fact is known, perhaps, to other ants also for they seldom come near its nest. But should they ever happen to pass close by it, they have to suffer the painful consequence of their negligence. A *Diacamma vagans* ☿ was once thus chastised. It was walking in its usual leisurely fashion when some twenty or thirty of these red ants fell on it on my opening the Sann-hemp stick containing the nest. The *Diacamma* was very much disconcerted for all the *M. destructor* clung to it, curling their little bodies round its legs, and pinching with their mandibles. The big ant ran for its life, occasionally giving a jerk to the legs or passing them through the mandibles.

I have observed these ants attending *Coccids* (*Dactylopius* sp.) on a wild bush.

Monomorium latinode, Mayr.

A portion of the trunk of a tree was scooped out, and the wood inside the hollow appeared to be decayed. On removing a few chips

of wood I found regular chambers and galleries made therein, thickly inhabited by workers, pupæ, larvæ and eggs of *Monomorium latinode*.

Iridomyrmex anceps, Roger.

This species nests in sandy soil near the roots of plants infested with Aphides. In case the nest is situated in an open place, Aphis-infested plants are sure to be found in the vicinity. Well beaten tracks diverge from the nest into different directions and these tracks appear prominently in sandy soil after a shower of rain.

These ants have been observed attending Aphides on a plant locally known as Mukna (*Leppia nodiflora*). On each flower and between the leaves about a dozen of these were present. A species of Membracid on Sissu is also attended by this species, and I have seen these ants visiting the sugary glands of *Cassia orientalis* also. Dead insects even receive their attention. I saw some 40 or 50 workers of this on a dead 'Mole cricket' (*Gryllotalpa africana*, Pal. B) and one worker was noticed once carrying a dead Sphegid wasp (*Crabro sp*).

In the same area there may be several nests separated from each other by a distance of a few yards only, but all belonging to a big central one. Workers of one nest can freely go into any other nest.

The nests are deep, but eggs and larvæ are always deposited in that layer of earth which is neither dry nor moist. In February these are found at the depth of barely one inch in large masses and in July at 10 to 12 inches depth, but only a few in number. Pupæ are naked, *i.e.*, not enclosed in cocoons. Winged males were obtained from the nests in August (20th August 1908). Living specimens of this species when squeezed between the fingers emit a peculiar kind of odour.

Tapinoma melanocephalum, Fabr.

Workers of this species have been observed attending (1) 'Wax scale insects' (*Ceroplastes* sp.) on Custard Apple (*Anona squamosa*), (2) Coccids on tender Bamboo shoots. (3) Aphides and (4) Caterpillars of *Catochrysops cnejus* F. (*Lycænidæ*).

The nests are situated underground, deep and very populous. Females have been secured in the month of July from the nests.

Œcophylla smaragdina, F.

This is the commonest ant at Pusa, and workers of this species are seen throughout the year. In cold weather they are not so active as during summer and the rains.

Their colonies exist on Lime, Mango, Litchi, Pipal, Jaman, Teak, Sissoo and many other trees. Nests are constructed of leaves folded and held together by white silky web, and are always distinguished by their large size from other small leafy constructions which are usually scattered all over a tree and are the "Cattle sheds" or "byres" of this ant.

FIG. 21.—WEBBING OF ŒCOPHYLLA SMARAGDINA ON PIPAL SHOOT ENCLOSING LECANIUM HESPERIDUM. (I. I. L.)

These byres contain generally Coccids—*Lecanium hesperidum* (on Sissoo and Pipal) (Fig. 21). Workers have also been observed attending *Lecanium nigrum*, *Icerya* sp., *Hilda bengalensis* and *Oxyrhachis tarandus*. Besides, they carry all sorts of miscellaneous insects to their nests, *e.g.*, caterpillars living or dead, dead grasshoppers, many flies, beetles, moths and sometimes their wings alone, bugs, small dead ants, etc. They congregate in large num-

bers on the trunk or near the foot of such trees as have their colonies on them. Should any living insect pass close by them, they would at once rush on it, and after killing would remove it to their nest. Their mode of attacking and killing their victims is very interesting. The following observation, which I quote from my note-book, will fully describe it :—

Pusa, January 30, 1908.—"A very curious thing I have noticed. There is a big pipal tree on the other side of the river Gandaki. On the trunk of this tree not very high from the ground I observed three workers of *smaragdina* dragging a helpless *myrmecocystus setipes*, ♀ maj., up the tree to their nest. I picked up the *setipes* and *smaragdina* workers also clung fast to it. On disengaging the *setipes* from the firm grip of *smaragdina* worker I noticed that the *setipes* was not yet quite dead. I knew that *smaragdina* was a great cattle tender; I had seen, on several previous occasions, the workers carrying to their nests dead insects pertaining to nearly all the different orders of insects. I have mentioned elsewhere their extreme fondness for living caterpillars, but I had never seen before workers of *smaragdina* carrying *setipes* to their nest living or dead. Had the specimen of *setipes* been dead, it would not have excited so much curiosity.

"I brought a stray worker of *setipes* to the foot of this tree where *smaragdina* workers were sitting in a large group. To ascertain whether there exist any hostile feelings between the two species I picked up the *setipes* by means of my forceps, and presented it to a group of three or four workers of *smaragdina*. These at once rushed on the *setipes* and one of the *smaragdina* firmly caught hold of one of the legs of the *setipes*. I at once removed the *setipes* with *smaragdina* clinging to its legs. I pinched severely the latter, but it did not let go its hold. I chopped off the abdomen, but the grasp was still fast. I cut off the thorax, but the 'Bulldog grip' was not loosened.

"Just as I turned my eyes to the other side of the trunk I beheld another interesting sight. Near the foot of the tree on the ground was stretched a *setipes* worker, its legs being in the tight

grasp of *smaragdina* workers. Each leg of the former was pulled out by a worker of the latter and was stretched as straight as possible, the *smaragdina* worker stretching itself in its turn, fixing the claws in the ground. Thus six workers of *smaragdina* were engaged with one worker of *setipes* which appeared more or less like a specimen on a setting board. At intervals it made a restless convulsive movement, but the grasp was all the more tightened. It began furiously to open and close the mandibles, but one more *smaragdina* worker very dexterously jumped and caught hold of the out-stretched jaw. The other jaw was similarly grasped by another worker. Thus the *setipes* was rendered motionless, and its escape hopeless. It was kept stretched in this 'set position' till it grew stiff (Fig. 22). A *smaragdina* worker occasionally loosened its hold to see if the victim contracted its leg, and if it did so, it was stretched with a vengeance. I watched this for half an hour when the *smaragdina* workers let go their grip one by one, leaving only three workers behind to remove it to the nest.

FIG. 22.—MYRMECOCYSTUS SETIPES WORKER BEING STRETCHED TO DEATH BY THE WORKERS OF (ECOPHYLLA SMARAGDINA. (FROM A PHOTOGRAPH.)

"To definitely learn the mode of *smaragdina*'s attack on *setipes* I brought another stray specimen of the latter; it was a worker minor. I left it close to the foot of the tree. It showed some signs of terror and was just running away when a *smaragdina* worker caught hold of one of its legs. The *setipes* doubled itself, attacked *smaragdina* in return with mandibles wide open, but was soon overpowered by an overwhelming majority of the enemy. As described above they 'set' it and in 15 minutes' time it was more than half dead

and was consequently removed up the tree. In this case only four workers joined in the attack, and in a comparatively short time the *setipes* was done with. The fact of the victim being a worker minor, accounts for less time and less number of *smaragdina* workers required to subdue it.

"To determine which is stronger of the two in a single-handed fight I put one *smaragdina* worker against one *setipes* worker. The former played its usual trick of grasping the leg and the *setipes* doubled itself to bite off *smaragdina*'s thorax. The *smaragdina* at once put its abdomen between the thorax and the strong mandibles of the *setipes* to obviously save the body from being cut into two pieces. The thorax of *smaragdina* is generally very narrow and delicate, and especially so at the apex of the metathorax where it is joined on to the abdomen, by means of a thin pedicel, the spot aimed at by the *setipes*. The abdomen was squeezed and drops of a colourless fluid oozed out. This fluid appeared to be offensive to *setipes* for it never turned its mandibles again that way.

"The *smaragdina* being light in weight was dragged by the *setipes* for a few feet, but it still firmly clung to one of the legs. The *setipes* tried hard to shake off the clinging *smaragdina*, but in vain. After fifteen minutes' close scuffle both fell exhausted in each other's embrace."

On several subsequent occasions I observed workers of *Œcophylla smaragdina* killing beetles (*Opatrum sp.*)* and bugs in the aforesaid "stretching" manner. On another occasion I noticed on the trunk of a Sissoo tree scores of workers of this species constantly walking up and down. In a neighbouring plot I found a plant badly attacked by caterpillars. I took a leaf of this plant which was covered all over with dirty coloured caterpillars, and laid it close to the trunk of the Sissoo tree. The *smaragdina* workers noticing the caterpillars fell on them voraciously. They mutilated

* I have even seen the giant Carabid beetle (*Anthia sexguttata*) attacked and overpowered by members of these red tree ants. The process of killing by stretching of the legs always seems to be practised when living beetles are attacked. Death is probably due to stretching of the nerve-cords of the victim.—F. B. F.

them, cut them up on the spot and then carried them off, up the tree to their nests. One thing I marked with a special interest in this connection. There was no strife between the workers over the distribution of the booty. Whosoever managed to lay its mandibles first on a caterpillar was acknowledged the undisputed possessor.

On this tree I found several small *nests* (I took them to be such at first) which consisted of a few, say 15 or 16, sissoo leaves rolled up and fastened together by the white silky web. On taking down and opening up two or three of such nests I found they did not contain winged sexes of this ant, but were solely occupied by the workers and a few larvæ. On green leaves which formed the inner apartments were noticed Coccids (*Lecanium hesperidum*) in large numbers. I concluded, therefore, that these small leafy constructions were not the nests, as I took them at first to be, but were the cattle sheds of the big colony of this species of ant, which had established itself on the tree.

The workers take very great care of their cattle: I have observed them on several occasions removing the Coccids very gently between their mandibles, from such leaves as get withered (on account of all the sap having been drained of) and laying them on to fresh leaves.

Like many other ants this species is also mimicked by spiders. In my collection I have two such spiders; and resemblance in the case of one spider to the ant worker is exceedingly striking. The pupæ of this species are found naked in the nest, *i.e.*, not encased in cocoons.

My friend Mr. P. C. Sen (Entomological Collector, Bengal) tells me that this ant is very common in certain parts of Eastern Bengal and Assam. Nests are generally found on mango trees, and consequently the workers of this species are very troublesome to mango pluckers in the mango season. On some trees they are so abundant that men cannot climb up for fear of their bite which is very painful. In such cases they pluck mangoes by means of bamboo-poles or some such other thing. This ant, though a serious nuisance in this way, serves a useful purpose on the other hand. In Eastern Bengal people tie a small basket to the end of a bamboo-pole which they raise and thrust into a big leafy nest of this ant.

A couple of sharp jerks are then given to the pole with the result that the larvæ, pupæ workers, etc., fall thick into the basket, which is taken down. To get rid of the workers and winged sexes handfuls of ashes are thrown into the basket. Larvæ and pupæ are picked out then and are used either alone or with powdered rice, as baits for catching fish.

It will not be out of place to quote here the following interesting note which appeared in the Journal of the Bombay Natural History Society, Vol. XIII, p. 536, under the signature of Mr. A. M. Long:

"The Murries of Baster—the southernmost Native State in the Central Provinces—use the red ants as a regular article of diet.

"Throughout the year, but more especially during the dry season, the Purjas—a sub-class of the Murries—collect nests of red ants and after tearing them open shake out the contents into a cloth and beat the insects mature and immature into a pulpy mass with a stone, and when all are dead enclose them in a packet, about the size of a goose's egg made of *sal* leaves. In this condition the article is taken to the bazaar and sold for a pice. To prepare the squashed ants for food they are mixed with salt, turmeric and chillies and ground down between stones, and are then eaten raw with boiled rice. They are sometimes cooked up with rice flour, salt, chillies, etc., into a thick paste: and in this condition the food is said to give the eater of it great power of resistance against fatigue and the sun's heat."

Economic—We have seen above that the workers of this species readily attack caterpillars, and consequently very few caterpillars are found, if at all, on such trees as have colonies of this ant established on them. Next we see that these ants tend Coccids and Membracids which are injurious insects inasmuch as they extract sap from the branches and shoots of trees on which they are found: but pipal and sissoo trees, on which colonies of this ant generally exist, are so vigorous and healthy in growth that the damage done to them by these Coccids and Membracids never comes to any appreciable amount. Again, we notice that in one place the larvæ and the pupæ of this ant are used as baits for fishes in another

place as an article of regular diet. Last but not the least, in removing to its nests dead insects and their broken limbs, which if left on the ground would rot and decompose, this ant does the work of a good seavenger. Taking into consideration all the above points, I am of the opinion that this ant is both beneficial and useful, although in valuable fruit gardens it is sometimes very troublesome.

Myrmecocystus setipes, Forel.

Ants of this species are common at Pusa and are found throughout the year. They make their nests underground and I have seen these both in hard and in sandy soils, and also in high banks of earth. If the nest is a long-established one, the entrance to it is more or less a transverse slit, and not circular as in the case of many other ants. Outside the nest there is to be seen a heap of earth dug and thrown out. The transverse slit and the heap of earth outside a nest are characteristic features of the nest of *Myrmecocystus setipes*.

I have not been able to ascertain definitely the inner structure of a nest, but having dug up several of these, I conclude that the main path in a nest, after the entrance, lies in a horizontal direction for a little distance, then it gradually goes deeper and deeper in an oblique direction, after which it branches off into different sides, leading to various chambers set apart for definite purposes, *e.g.*, the eggs and larvæ chamber, the pupæ chamber, the Queen's chamber, lumber rooms, etc. In the last named room all sorts of rubbish is thrown, such as empty pupæ cases, wings, hard integument and useless parts of insects brought into the nest.

Workers of this species carry all sorts of things and insects to their nest, such as fruits of *Ficus* trees, millipedes, grasshoppers, Neuropterous insects, wasps, ants, beetles, moths, bugs, etc., living winged and wingless Termites are also carried into the nest in large numbers. In the case of winged ones the wings are clipped off and thrown into the 'lumber room' and the wingless ones are carried into the store chambers, where they are packed in groups of twenty to thirty. Plundering habits of this ant have also been observed.

Once a worker of *Iridomyrmex anceps* was carrying a dead Sphegid wasp (*Crabro sp.*) and a worker of *setipes* waylaid it. The last named caught hold of *anceps* and violently shook it with the dead wasp. The wasp dropped from the grasp of the *anceps* and the *anceps* from that of the *setipes*. The *setipes* could neither see the wasp nor the *anceps*, although both were lying close to it on the right hand side. The *setipes* commenced a search in the opposite direction and in the meantime another *anceps* turned up on the scene and both the *anceps* carried away the dead wasp. As regards the sight of these big ants, such as *Myrmecocystus setipes*, *Camponotus compressus*, *Sima rufonigra* and the like, my belief is that they can see in particular directions only. I have noticed workers of these grappling with their victims on different occasions and generally missing them after the first onslaught, though they were lying quite close by.

In the last week of March 1908 at Wazirabad and in the middle of April 1908 at Lahore (Punjab) I got beautiful winged specimens of a male ant. Most of these were collected on the banks of the Chenab and on wet soil, but on two different occasions I captured a couple of these near the entrance to a nest of *Myrmecocystus setipes* under circumstances which made me suspect these to belong to the nest, and to be the males of this species. This point was established when in March 1909 on my digging up a populous nest of this ant I found nearly a dozen insects, similar to the supposed males, running out of the nest. These males can fly to a very great height and (unlike other winged ants) cannot be caught easily by hand.

In the "Fauna of British India; Hymenoptera." Vol. II. p. 312, only the worker of this species is described; the females of this species were secured by me long ago and there was no difficulty experienced in identifying them, for the workers and the females are almost identical in general appearance, only the former are smaller and wingless and the latter larger and winged. The male bears no resemblance either to the female or to the worker in colour or appearance. I describe it as follows:—

Myrmecocystus setipes. Forel. ♂ (Plate XIV, Figs. 7 & 7a). Head not so broad as the thorax, covered from behind with long glistening silvery white hairs; mandibles narrow near the basal portion, wide in the middle, and having the apical portion formed into an acute triangular tooth, close to which there is another blunt tooth on the inner margin. On the outer surface there are a few large shallow punctures and long pale hairs: antennæ 13 jointed, scape very long, equal in length to about 8 basal joints of the flagellum; clypeus convex; eyes large and prominent; ocelli distinct, placed in a triangle on the vertex: a distinct fovea in front of the anterior ocellus, and from this runs a smooth longitudinal line down to the top of the frontal area. Thorax compressed; pronotum slightly below the level of the mesonotum which is convex and bears in the middle a smooth longitudinal line: scutellum prominent; metathorax gradually sloping towards the apex, covered with short, soft, white recumbent pubescence. Node of the pedicel is convex in front, concave from behind, covered with a few long white erect hairs. Abdomen cylindrical, segments glabrous above, their basal portion constricted, ventral side covered with long pale hairs. Genitalia very large, exserted. Head and thorax black, chalybeate in certain lights, remarkably so in fresh specimens. Legs (excepting coxæ, trochanter and the basal portion of femora which are black), apical joints of flagellum and the abdomen ferruginous. Wings hyaline, the nervures thick, radial cell fuscous.

Length 12 mm., expanse 17 mm.

Acantholepis frauenfeldi, Mayr., var. *bipartita*, Sm.

This is one of the fast running ants and is easily confounded with the other small black ant (*Prenolepis longicornis*, Latr.) which also runs very fast. I have seen the nests of this species underground near the foot of trees, bamboo clumps, and in cracks and hollows in pucca masonry. The workers are generally found running up and down the trunk of such trees as *Tectona*, *Delbergia*, *Ficus*, etc. Evidently they have their cattle byres on these trees for the ants that descend invariably have their abdomen considerably distended.

Once I noticed them congregating in large numbers on smoked combs of *Polistes hebræus* and *Apis florea*. F. These ants have been observed to attend Aphides on Ak (*Calotropis gigantica*) and Coccids (*Lecanium* sp.) on orange trees, and also to carry dead insects to the nest. Winged sexes have been obtained from the nests during July and August. Pupæ are encased in cocoons.

Prenolepis longicornis, Latr.

The nests of this species are generally underground and the entrance hole is sometimes covered with dead and fallen leaves. Once I came across a nest which was located in the trunk of a fig tree, just near its base. There was a big hollow in the trunk about a foot and a half from the ground. Inside this the wood was decayed and reduced to soft pulp. On my removing this soft woody material from one side I found underneath it countless workers, larvæ and eggs of this species and also tunnels and galleries leading far inside into the trunk.

From another nest which was discovered near a thatched house, and was hidden from view, being covered over with dead leaves, I secured a specimen of *Merismoderus bensoni*, Westw. (Paussidæ). This is one of the fast running species of ants.

Camponotus compressus, Fabr.

This species is very common at Pusa, workers being seen almost throughout the year. During the rains they become abundant, but get scarce towards winter.

The nests are generally found underground at the foot of trees and bamboo clumps. They are sometimes found in the walls of houses also.

On account of its sugar-hunting habits and excessive fondness for sweets this species becomes a regular nuisance, during wet weather, in store-rooms where jars of sugar and pots of jaggery are left without tight covers. The workers feed on dead insects also. The fleshy portion is extracted and consumed on the spot, but when a worker succeeds in chopping off a larger slice of flesh, it is seen

trotting off to the nest with it. Once I noticed them carrying the pupæ of *Apis florea*, F., which they extracted from the cells of a comb fallen on the ground.

This species is a well known 'cattle tender' and the workers have been observed feeding on the honey-dew exuded by :—

1. Membracids (*Oxyrhachis tarandus*, Fabr.) on Babul (*Acacia arabica*.).

2. Cercopids (*Machærota planitiæ*, Dist.) on Ber (*Zizyphus jujuba*).

3. Aphides : (*a*) on vegetable beans.
(*b*) A greenish-blue species on Maize (*Zea mays*).

4. Coccids : (*a*) *Asterolecanium miliaris*. Boisd. var. *robusta*. Gr., on Bamboo.
(*b*) *Dactylopius* sp. on a wild bush.
(*c*) The Lac Insect. *Tachardia lacca*, Kerr.

This ant is a source of regular annoyance to the lac grower. In their eagerness to obtain 'honey-dew' the workers of this species often nip off the white filaments, the two anterior of which are connected with the respiratory apparatus of the Lac Insect. the Coccid being killed consequently.

This species has been observed at Pusa to attend the caterpillars of *Catochrysops cnejus*, F. (*Lycænidæ*) also. Three or four workers may be seen with a single caterpillar at a time, some stroking it with the antennæ and others getting on its back. The caterpillar does not resent the overtures of the ant and in some cases it has been found essential to keep the ant and the caterpillar together for the successful rearing of the latter.

The caterpillar discharges through a crescent shaped aperture situated on the 7th segment a drop of a white, very slightly viscous fluid which is greedily licked off by the ant. The caterpillar can close or open this aperture at will, and, through the middle of this the fluid is exereted. The ants are in the habit of examining, rather feeling, this portion with their monthparts from time to time to ascertain if any fluid has collected there.

On days of brisk showers followed by close atmosphere during the rainy month of July the winged sexes of this species take flight just at the time when darkness sets in. On such evenings scores of females and males of this species are attracted to light.

A worker major was once observed moving about with the underside of the thorax touching the ground, the whole body stretched to its full length, turning the head from left to right and *vice versâ*, as fast as its massive ugly size admitted; in short, it was in an extremely annoyed and perplexed condition. I could not understand what had troubled it. After a closer examination I noticed a small reddish ant being very roughly caught, squeezed and lastly mutilated by the worker major. I picked up the small ant, but the corpse was too mangled to be identified. On subsequent occasions whenever I saw a worker major of this species in this dazed condition I was sure to find some dead or dying small ants close by. I have also witnessed *compressus*' wholesale massacre of the helpless Termites whenever the latter happened to be open to view.

In this species, I think the colony is founded by a fertilized female singlehanded. On three different occasions, while digging up some nests, I found an oval chamber inhabited by a single female of this species with about half a dozen young larvæ and two or three cocoons.

Polyrhachis simplex, Mayr.

I reproduce here my note on this species which has already appeared in 'Indian Insect Life.'

"Nests of this species are found on low bushes, high trees, under bamboo sheaths, and on sugarcane leaves. The nest is always constructed in such a way as cannot be easily discovered by a casual eye. A greater portion of it is covered over by leaves and the portion open to view is not easily recognisable. It looks from a distance as if it were made of clay and cowdung mixed with dry pieces of leaves, straw and grass. In reality it is a brown silky cobwebby material, over which are thickly and closely laid dry pieces of leaves,

straw, etc. Just as *Œcophylla smaragdina* workers make use of salivary threads secreted by their larvæ in folding the edges of leaves together, so do the workers of this species. They catch hold of the larvæ between the mandibles and carry them over to the places where the web is required to be spread. The larvæ go on laying and stretching threads mechanically as wanted. Other workers bring dry pieces of straw and spread them over the web while it is still fresh. When a nest is cut open from any part a few of the workers at once rush up to the spot and plant themselves as sentinels to guard the breach, while others remove to a secure place larvæ and pupæ or whatever be in that portion of the nest. After the chamber opened to view is cleared of what it contained, the workers hold the torn portions between their mandibles and pull inwards. Thus the aperture is made as narrow as possible, and then a couple of larvæ are brought and the web is drawn across the rent in the usual way. The whole inside of the nest is lined with the brown silky cobwebby material, and the partitions between different chambers are also made of this material, but without straw.

"Ants of this species also tend cattle for whose protection they prepare byres of the same cobwebby material and cover also in a similar manner as their nest. Such byres were found on a sugarcane leaf, and also on a weed, close to established nests of this species. Workers were seen going in and coming out of those cattle sheds. On removing the covering large clusters of sugarcane Aphis were found in the former and *Monophlebus* in the latter shed. Workers of this species have also been observed carrying a large dead fly to their nest. Pupæ are encased in light brown cocoons. The winged sexes were obtained from nests in August and September."

It has been said in the foregoing pages that the pupæ of *Œcophylla smaragdina* are naked, and those of *Myrmecocystus setipes* encased in cocoons. *Smaragdina* nests in trees, and *setipes* underground. The larvæ of the former produce silk threads and so do those of the latter. The former uses them in binding together the leaves of trees for the nest and the latter in spinning cocoons inside which

they pupate. The question, therefore, arises why should not the larvæ of *smaragdina* pupate inside cocoons when they can produce so much silk as enables them to prepare nests of such large dimensions; and why, on the other hand, should *setipes* not nest on trees when the larvæ can secrete silk thread which may be used for folding the leaves together? If it be urged that the *smaragdina* larvæ do not spin cocoons because they find the inside of the leafy nests quite soft and sheltered I shall quote the instance of *Polyrhachis simplex*, which to me appears to occupy an intermediate position in this respect, between the two species. The ant nests on trees, the larvæ are used like those of *smaragdina* for constructing the nest, all the apartments are lined with silk from inside, and yet the larvæ pupate inside cocoons. If, on the other hand, in the cattle tending habit of *smaragdina* and *simplex* is found an explanation for their nesting on trees, then the position of such ants as tend cattle, but nest underground, becomes unaccountable. In this connection *Iridomyrmex anceps* and *Camponotus compressus*, etc., may be taken as examples. If there is any particular reason or motive in this, perhaps the ants know it best; at least it is beyond my comprehension.

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